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THE PANAMA CANAL: SOME SERIOUS OBJECTIONS TO THE SEA LEVEL PLAN.

By Major Cassius E. Gillette.*

Perhaps the most important engineering problem that ever required solution is that of the plan for the canal across the Isthmus of Panama. The cost involved is almost beyond the grasp of the imagination. Even the difference between the least and the most expensive plans that have received serious consideration is equal to the cost of almost any one of the greatest engineering works of the world. Under these circumstances any plan that gives any prospect of success and economy should be carefully considered.

In general, that plan for any engineering work is best which accomplishes the desired object at the least total cost.

In the case under consideration the object is the passing of the present and future commerce of the world with certainty, safety and reasonable promptness. The last consideration, however, is of limited importance, since the voyages concerned will be mostly measured by thousands of miles in distance and by weeks in time. Hence whether it takes six hours or twelve, to pass the canal is a matter of small moment.

The cost of the canal is made up of the first cost, the cost of operation and maintenance, and the cost of enlargement. The cost of enlargement is a very important matter, as can be seen by the history of existing canals. The old state canals of Ohio and Pennsylvania, once great arteries of commerce, are now almost useless on account of their small size. The Erie canal has been once enlarged, and $101,000,000 is to be spent in rebuilding it to suit 1,000-ton barges.

The original "Soo" lock, built about fifty years ago, has been twice augmented by a new lock, each much larger than its predecessor. The Suez canal has been enlarged once, and is now too small.

In 1854 the United States nearly completed a convention with Granada to build a canal at Panama. Had one been built of an appropriate size for that date and not enlarged, large ships would to-day doubtless be going around Cape Horn in successful competition with boats small enough to go through the canal.

Some one has said that the best pavement for American cities is the one that can be most easily dug up. Similarly, it might almost be said that the best Isthmian canal is the one most easily rebuilt on a larger scale.

Most reports and writings on the subject seem to take it for granted that a sea level canal is the only one that will fulfill this important condition, but such a conclusion is by no means borne out by the facts.

Another seemingly off-hand conclusion that has been announced in nearly if not quite all of the reports of commissions and technical committees on the subject, is that a dam is not practicable at any site north of Bohio. Up to quite recently this pronouncement never appears to have been based on any borings, or other ascertained facts. The Chief Engineer and the Engineering Committee of the recent Commission came to the same conclusion as regards the proposed site at Gatun, this conclusion apparently being based on two borings.

The advantages of a canal involving a high dam at Gatun,* are so great in the controlling elements of cost, time of construction, serviceableness and ease of enlargement, that the discovery of the best location and the devising of a dam that will successfully fit that location, are problems worthy of the most thorough study and research.

To point out these relative advantages, and to suggest a possible solution, the following article has been prepared:

The map (Fig. 1) gives the principal localities necessary to the discussion. It will be noted that the upper Chagres River is on the east of the canal line, while the mouth is on the west. This crossing of the river by the canal introduces, perhaps, the most serious element into the problem. The river flow must be taken into the canal, or the stream must be kept on the east side throughout, since it is wholly impracticable to carry the canal across the river on a viaduct, as has been done in the past with small canals crossing moderate streams.

Another factor of vast importance, which, however, has received scant consideration in the past is that of sediment. This has generally been dismissed with the statement that the upper Chagres is not a silt bearing stream. The writer has known an ordinary canal, 50 ft. wide and 5 ft. deep, to be filled to the surface with mud in a few hours by a "clear water" brook that one could step across in ordinary stages. It does not seem that this subject of sediment deposit has been given the consideration in Panama canal plans that its importance warrants.

The upper Chagres is doubtless a clear-water stream at low stages, but how much sediment it actually carries in floods seems never to have been measured. Its condition at present, too, is no guarantee of what it will be when the canal is opened. At present the tropical jungle is so thick that no matter how hard it rains the water only reaches the ground gradually, and flows off slowly through the mass of ground verdure, so that it can cause little or no erosion. When the French company had a large force at work, a large area of this jungle was cleared and put under cultivation to raise supplies for the workmen. The same thing will occur again when the canal force is augmented, and it may be expected to continue indefinitely, since passing ships and regular trade will doubtless furnish a market for all the bananas that can be raised as far up every stream as a canoe can be pushed. The country is made up of very steep slopes of volcanic soil, easily eroded, and every stream that flows into the canal will become a menace to it. The evil could, of course, be lessened by buying the land and forbidding agriculture, but this would be expensive, and would lose to the world the agricultural

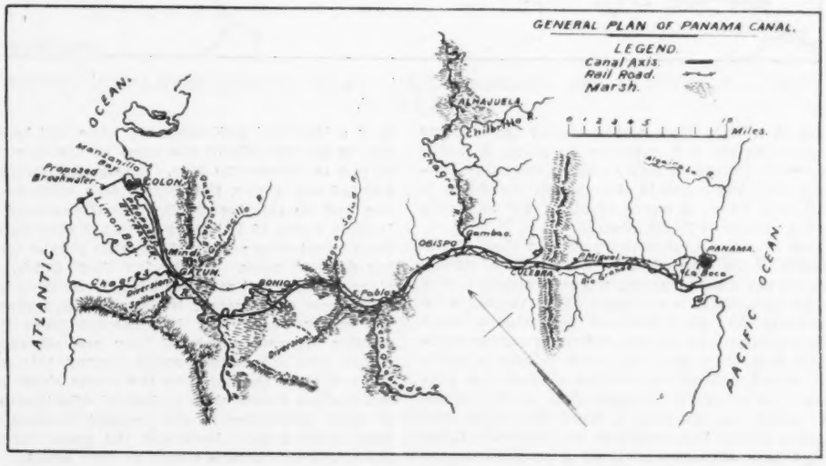

FIG. 1. GENERAL MAP OF THE PANAMA CANAL.

ture of a very rich region, whose products would probably be quite valuable to passing ships.

The map (Fig. 2), shows that portion of the canal line from Culebra to San Pablo a distance of about 15 miles, where the sediment question is the most important. The valley here is narrow, and the present river surface at Gamboa is about 55 ft. above sea level.

The problem of disposing of the sediment of all these streams, if a sea level canal be adopted, is a serious one. The canal must occupy the bottom of the narrow valley and its water surface, if on the sea level plan, must be no less than 55 ft. below the present river surface, its bottom 35 or 40 ft. lower still, while its banks are of easily eroded material. The sediment from even the smaller streams cannot be neglected. The Mandigo River, for instance, seems to have a drainage area of ten or fifteen square miles, and as it is on the Atlantic side of the divide, it must be subject at times to torrential floods.

The sediment question has generally been dismissed with the simple proposition to dredge the mud as it is deposited, but this, in addition to the

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*This location, the writer believes, was first suggested by Mr. C. D. Ward, M. Am. Soc. C. E., in 1879.

very large perpetual cost, would, at least in the above section, require a canal practically of double width—one width for traffic and the other for dredges and scows. (It is assumed that the estimates for a sea level canal have not been based on a width great enough in deep cuts for large ships to pass each other, except at special points).

Another element of the problem that does not seem to have been given the consideration it warrants, is the difficulty of large ships navigating the present Atlantic end of the canal in the high winds that prevail in that vicinity. The present entrance, which forms a part of all plans that have been considered or recommended, is especially dangerous. A large ship, trying to pass the sharp reverse curve necessary to get into the canal in a high wind, would almost surely come to grief unless the entrance be given a width great enough to practically abolish the curve. Another very bad curve in the present canal line is at Gatun, where a curve of about 45° is shown with a radius of 3,000 meters.

The writer ventures the assertion that if the velocity of the high winds and the radii of curvature of the above curves, were furnished a few of the captains of our largest ocean vessels, with a request that they indicate how wide a canal they would require at such points to render navigation safe, their opinions would call for a width that would add an astonishing sum to the estimates. A perfectly straight cut, as shown by the dotted line on Fig. 1, from Gatun to deep water in Limon bay, would go far to remedy these things, as a ship can navigate a straight course in a comparatively high wind, especially one directly ahead or astern, as would be the case with the cut suggested. Further up the river are many other bad curves, but they are somewhat less objectionable, as the wind is less, and the forest gives some protection. But even without wind they add greatly to the difficulties of navigating large ships.

Bearing in mind the above considerations, let us now compare the advantages and disadvantages of various general plans for the solution of the problem:

THE SEA LEVEL CANAL.

GENERAL DESCRIPTION.—The plan involves a dam at Gamboa rising to a height of 200 ft. above tide, with a masonry core wall down to bed rock, the main dam to be built from the spoil from the Culebra cut. This dam is to act as a regulator for the Chagres River, the flow to be discharged at a uniform rate, either into the canal by suitable waste gates, or into a diversion channel by these gates, or by a tunnel 3.4 miles long, into the Gatuncillo, thence into the diversion channel further down stream.

COST.—The estimated cost of this canal, 150 ft. wide at bottom, and 35 ft. deep, is $230,475,725, and the time required to build it, from ten to twelve years.

OPERATION AND MAINTENANCE. — The sediment of the upper Chagres is disposed of in this plan by the above high dam, but that from the other tributaries is not. Those on the left bank of the river below San Pablo can be easily kept out by a continuous levee, as the flat land is wide. On the other side the canal at several places is quite close to the hills, and much erosion of the levee on this side, with frequent breaks, may be expected. This is especially true of the long diversion proposed for the Gatuncillo. The channel planned for this is large enough for the water, but the Gatuncillo in flood carries a very large proportion of mud, even now, and the narrow, deep channel will probably soon fill up so that a long and well-protected levee will be necessary on that side of the canal all the way from Gatun to Manzanillo Bay. Above San Pablo, as pointed out above, the matter is a very serious one and no solution for it has yet appeared. A bottom width of 150 ft. is certainly very narrow for a canal where large ships must pass a dredging fleet at work. Thirty-five feet depth, too, gives a very small margin under the keels of large ships now constructed, let alone future growth, and many floods may be expected from these smaller streams which, if they are allowed to empty into the canal, would destroy this margin and close the canal to the larger ships until the dredges should clear a channel. The likelihood of ships grounding in the crooked channel has been pointed out above and the speed through the restricted channel would be very small.

The ordinary time of transit, and the delays due to blockade from accident, are probably both greater in a sea level canal of the width, depth and curvature involved in the above estimate, than in a canal provided with locks, but with otherwise suitable dimensions.

EASE OF ENLARGEMENT.—As stated above, it has generally been considered that the enlargement of a sea level canal is an easy matter, but when it is remembered that this will involve the subaqueous removal of rock for a width of something more than 150 ft. for a distance of from 15 to 20 miles, the work beginning at 35 ft. below low water, and being carried down to 40 or 45 ft., whatever is determined on as the new depth, it will be seen that the expense involved is a tremendous one. Moreover, when such deepening is demanded, ships will be using the canal, loaded to the maximum permissible draft, and many of them are likely to be sunk by striking rocks scattered by the blasting.

At least a portion of the fourteen miles of canal through Culebra cut is to be held between masonry walls to prevent the water disintegrating the soluble clay in the banks. To tear out at least one of these walls and replace it subaqueously will be no easy problem. In other words this part of the canal will surely have to be made large enough in the first place, and anything like a liberal estimate of future demands will call for an appalling increase in the required funds.

The proposed 30-ft. tunnel spillway, 3.4 miles long, is a rather dubious proposition. The bottom of this tunnel is to be 68 ft. below the crest of the Gamboa dam. It will probably be inaccessible except once a year for a short period. Water is to flow through it at the rate of 20 ft. per second. Erosion may be excessive, and repairs may be difficult. It passes through a country that is badly shattered, broken rock and soft material being mixed without much system. An earthquake or other accident might block the tunnel. Should the dam be overtopped, the down-stream backing would melt away, the masonry core break, and the whole mass be rushed down the valley to the complete ruin of the canal. The only safe plan is to provide a spillway of ample dimensions. The spillway provided at Bohio for a discharge not greatly in excess of that at Gamboa, with a regulating lake of about the same size, is 2,000 ft. long, with a maximum depth of 7 ft. If this, or a shorter spillway, is provided at Gamboa, at a height of 200 ft., the dam must be raised 7 ft. or more.

The utility of the masonry core wall to this dam is not patent. It really converts the dam essentially from an earth and rock structure into an inefficient masonry one. By stopping all seepage of water, the rock and clay fill above the dam becomes thoroughly saturated, and the large proportion of soluble clay in its composition would make it, so far as pressure is concerned, a fluid heavier than water, with a correspondingly increased thrust. The down-stream fill would be completely drained, and could not be brought to an efficient bearing until it had been compressed by the pressure of the masonry dam against it, which would involve a yielding of the structure. The conditions then are highly favorable for a rupture of the core. The advocates of a similar structure at Bohio claim it gives no added strength to the dam, but saves water that would otherwise percolate through and underneath the dam. Granting for the moment that this may be true, there is no apparent need of such action at Gamboa, as the omission of the masonry core would only cause the addition to the canal of a moderate amount of filtered water.

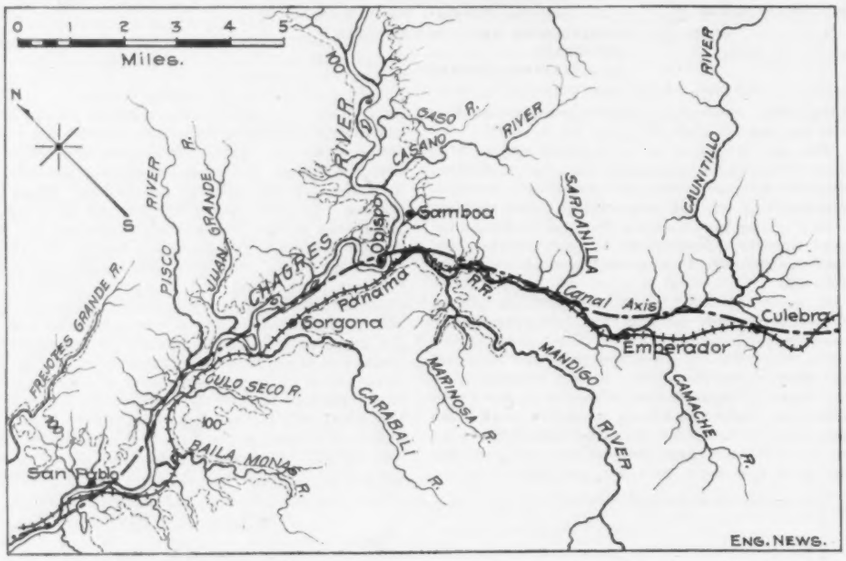


FIG. 2. PORTION OF THE CHAGRES VALLEY WHERE SEDIMENT DEPOSITION IS MOST IMPORTANT.

THIRTY-FOOT LEVEL CANAL.

GENERAL DESCRIPTION.—(All canals involving locks will have a short portion of sea level canal between the terminal lock at each end and the ocean.)

The 30-ft. level involves either a canal with built-up banks, or a dam at each lock forming a pool of moderate size. The former is wholly out of the question, as the banks would constantly be liable to rupture from burrowing animals or malicious persons, so that the navigation provided would not be reliable. The small pools provided by the plan with dams would not control the flow of the Chagres, but would make its diversion more difficult, while in the narrow parts of the upper valley the canal would be constantly menaced by the sediment from all the smaller streams.

A 30-ft. canal has been proposed in which the Chagres flow is to be divided at Obispo, and one-half of it sent in each direction in the canal itself; 30-ft. dams being provided at Mindi on the Atlantic side, and near La Boca on the Pacific.

It is doubtful if sites for these dams can be found that will not require them to be of excessive length—practically long levees. The trouble with taking one-half the flood stages of the Chagres into the canal is that at Obispo there would be a fall of 25 ft., and the swift current there, and at all curves below, would erode the banks and fill up the canal. In other words, the floods would make a river of the canal, with caving banks, deep eddies and shoal "cross-overs." This river would be somewhat regulated by the Gamboa and Alhajuela dams proposed, but there would still be strong and variable currents.

To protect the banks against this would involve an enormous expense. Assuming this to be done, the trouble with sediment would remain. The plan provides for permanent dredging at the "forks" at Obispo, where a small triangular pool is provided. The velocity through this in floods would be so great that only the coarsest detritus

would be deposited; the rest would have to be dredged out at many points below. This would require a canal of great width down the pools, and a great continuous expense for dredging.

COST.—The estimated cost of a 30-ft. level canal is given by the Chief Engineer as $194,213,-405. This is based on a lock and spillway at Bohio, and a controlling dam at Gamboa.

The 30-ft. canal with the divided flow of the Chagres is estimated by its projector at less than $140,000,000.

One great advantage that pertains to the 30-ft. level canal, and to all plans involving a navigable lake above the dam, is that the future enlargement through the Culebra cut can be provided for by simply raising the dam and spillway and building extra locks of the required dimensions.

SIXTY-FOOT LEVEL CANAL.

GENERAL DESCRIPTION.—This involves a dam, locks, and spillway at Bohio, and a controlling dam at Gamboa.

COST.—This is put at $178,013,406.

OPERATION AND MAINTENANCE. — The dangers and difficulties pointed out above in connection with the high Gamboa dam, pertain to this canal. It would lessen, but not remove the sediment troubles above San Pablo. It would involve two large dams instead of one. It would

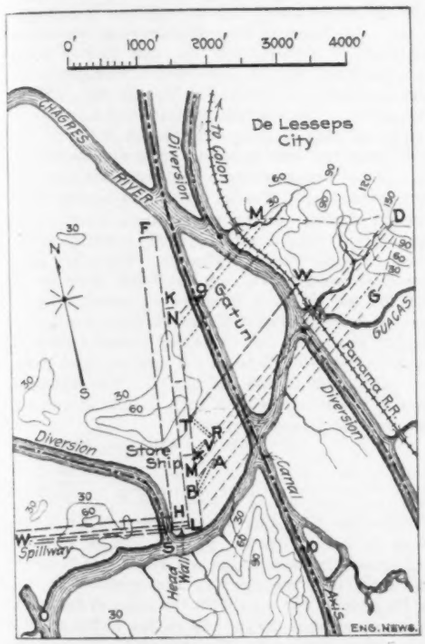


Fig. 3. Plan of Propcsed Dam at Gatun.

provide only a comparatively small lake for regulating the Chagres floods, making inconvenient fluctuations, with added dangers of overtopping the dam. The difficulties of construction would be great. It is very hazardous work to attempt to construct an earth dam, with or without a masonry core, in a narrow valley, without first diverting the water. To construct a temporary spillway at the low water level would be an expensive operation at the Gigante site, and a risky one at the lock pit. When completed there would still remain 18 miles of sea level canal to construct below the dam, with the difficulties in the diversion of the Gatuncillo and other small streams on the east of the canal.

The approved plans of this dam involve a masonry core, put in by the pneumatic caisson process, and extending down to bed-rock, about 163 ft. below low tide, or, what is about the same thing, below local low water in the river. The expense of this would be enormous, and its feasibility very doubtful.

In a paper on the subject (See "Transactions, Am. Soc. C. E.," Vol. 48), the late Mr. George S. Morison demonstrated that this core is not necessary to limit seepage. It certainly is not needed for anything else.

85-FT. AND 97.5-FT. LEVEL CANALS.

There have been proposed, with a dam, spillway and locks, at Bohio, with or without a water supply dam at Alhajuela. For the 85-ft. level, the dam at Gamboa, to arrest sediment as well as store water, would probably be necessary, instead of the Alhajuela dam. The pool of the 97.5-ft. level would extend far enough up the Chagres above Obispo to form an efficient settling basin. The 85-ft. canal would not be troubled with the sediment from the smaller streams so much as the 60-ft. level; and the 97.5-ft. level would be affected still less. The pond, however, should extend a mile or so up each stream that flows into

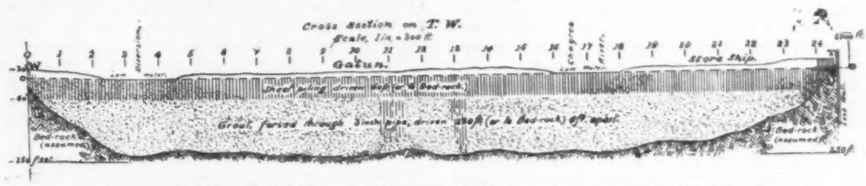


FIG. 4. LONGITUDINAL SECTION OF PROPOSED DAM AT GATUN, SHOWING METHOD OF MAKING WATER-TIGHT WALL THROUGH CENTER OF DAM.

the Chagres between Emperador and San Pablo, which would apparently require a level of about 100 ft. Both these plans include two high dams and the eighteen miles of expensive sea level canal below Bohio.

100-FT. LEVEL CANAL.

Obviously, from what has gone before, a 100-ft. level, with a dam at Gatun, is the most advantageous plan, unless the same dam could be located further down stream. This is forbidden by the topography, the range of hills crossing at Gatun being the farthest one north that has sufficient height. Such a dam would give a lake having an area of a least 100 square miles, subject to very slight fluctuations, and capable of settling for ages all the mud that the streams would bring into it, and with no current of moment in its narrowest parts during the highest floods.

In the dry season it would have for lockage, not only the flow of the Chagres proper, but its own immense storage, and the flow of the Trinidad, Gatuncillo, and other numerous tributaries located in the region of heaviest rainfall. The dam could be built of the spoil from the Culebra cut, and its cost per ton would be only the cost of hauling it about 25 extra miles. It has to be loaded on the cars and hauled several miles and be dumped in any event. Moreover, dump grounds of the necessary capacity are not plentiful near Culebra, and it is quite probable that the later excavation may have to be hauled quite long distances.

By such a dam all the expense of the nine miles of crooked canal between Bohio and Gatun would be saved, and replaced by the open navigation of a broad, deep lake. The Gatuncillo would be taken into this lake and all trouble from it removed.

The saving in cost would be so great that the funds now authorized could probably cover also a canal through the summit cut deep enough and wide enough for all future needs, as well as a deep and wide straight entrance to the locks from Limon Bay, both conducing to safety and celerity of passage.

To attain these important results, the following general plan, based on what the present state of knowledge of the locality indicates as probable conditions, is suggested:

The island (Fig. 3) on which the lock for present needs (L. K.) is shown is, at least at its upstream end, of rock or firm clay suitable for a lock foundation. The ridge running from S to W where the spillway is shown is undoubtedly rock. The diversion cut, started at O, was abandoned, and had to be moved over to S before a soft place could be found. The depth of rock at S is unknown, but it is doubtless only a short distance. This forms an admirable foundation for the concrete spillway.

The site of the dam, whose crest is shown at D. M., is apparently sand and gravel, possibly 200 ft. to bed rock. The dam shown is 200 ft. wide on the crest, 120 ft. high, and 2,000 ft. wide on the base. It contains about 18,500,000 cu. yds. of material which, at an estimated cost for hauling of ½ ct. per ton mile, or about 15 cts. a cu. yd., would amount to $2,800,000. This dam would be amply wide and heavy to be safe against rupture from any imaginable cause.

To stop seepage through the dam itself would be a simple matter. If the upstream portion is made of clay and other finer materials protected by rocky material, and the rest of the dam mostly of coarser material, seepage will be unimportant. Seepage under the dam through the "water-bearing" material which fills the alleged "geological valley," seems to have caused more alarm than need be. The fear is that it would let too much water escape in the dry season. Assuming that the minimum cross section under the dam has a width of 2,000 ft. and an average depth of 200 ft., which seems to be ample, we would have a cross sectional area of 400,000 sq. ft. Regarding this as a filter bed with a thickness of 2,000 ft., it scarcely needs demonstration to show that the yield of such a filter would be relatively unimportant to a lake of 100 square miles of area, which would be receiving the flow of the entire Chagres basin at the same time. With large quantities of fine mud brough down by the Gatuncillo, together with the foliage from the submerged jungle, the filter would soon clog completely.

However, to dissipate all doubts on the subject, the sealing of the valley is a comparatively easy matter. Interlocking steel sheet piling can be driven, say on the line W. T., to a depth of, say 60 ft., as shown in the sketch, Fig. 4.

This would greatly reduce the "filter" area. Then, immediately alongside this line of sheeting, 3-in. pipes could be driven in succession to bed rock 5 to 6 ft. apart, and thin Portland cement grout, made of specially finely ground cement, forced down each under a pressure equal to 100 ft. head of water, and the pipe gradually pulled up as to the flow of grout ceases.

If the pressure of the future lake, 100 ft. deep and a thousand or more feet away, will force any water through the material of the filter on this line, the pressure of the pump should force the grout into the surrounding material with a greater velocity and force. Hence, if the future seepage is to amount to anything, the pump pressure will force the grout into enough of the surrounding material to convert a sufficient thickness of it into tight artificial rock at a very trifling expense compared with a masonry core. If steel sheet piling rusts away, the iron and lime cement formed by the process will make a tight joint. The sheet piling is necessary because near the surface pump pressure might force the grout up alongside the pipe instead of into the sand and

Fig 5.

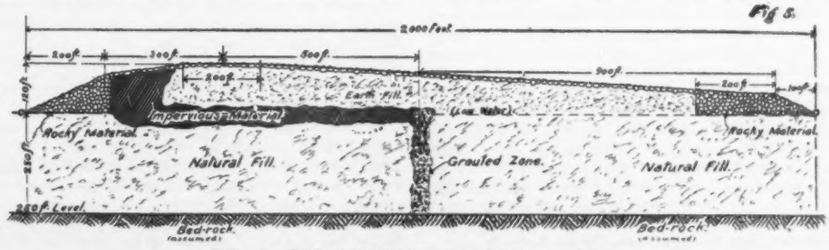


FIG. 5. CROSS-SECTION OF GATUN DAM.

gravel. If any layers of impervious material are encountered that will not take up any cement, it will be because they are tight enough already and do not need it. Of course there is no danger of such a cemented water tight wall being ruptured by pressure, because it would be backed by unlimited material settled in place for ages. Should any compressible material exist, the weight of the dam over it would promptly squeeze it down tight and solid. There is no probability of such compressible material below the proposed sheet piling.

Of course, the vegetation, surface mould, etc., should be dredged away from the water-tight section to the zone of impervious material in the upstream portion of the dam. A cross section of the suggested dam is shown below in Fig. 5. Both the dam and the grouted zone are, in general, essentially similar to structures mentioned in the above paper by Mr. Morison, and its discussion. This discussion clearly demonstrates to the writer's mind that the plan would be successful at Bohio. If so, there is no imaginable reason why it would not work at Gatun.

If the grouted zone and sheet piling are used the width of cross-section of the dam can be considerably reduced.

The surface of the dam should be largely of rock, with an area near the crest composed of rock too large to move by hand. Then, if a forest of trees, with interlacing roots, be planted all over the surface, the dam is proof against accident or design. Needless to say, possible damages by crawfish or muskrats are easily prevented in such a dam.

The masonry tees, R. T., V. X., and A. B., extending from the lock wall, will effectively stop any percolation along the lock wall, and at the same time provide for the crest of the dam being ten feet above the wall. They should be built up from solid material.

The locks are assumed as of 900 ft. useable length, and 90 ft. useable width. This will take the largest ships afloat, or projected, that are likely to use the canal, with a good margin for future growth. When they become too small, another flight of any size required can be built in the space left alongside. When that in turn is outclassed, the old one can be rebuilt still larger, and so on indefinitely.

The lifts, beginning at the lower end, are 35, 35 and 30 ft., making 100 ft. to the level of the spillway. The upper wall is 10 ft. higher than the spillway, making it 5 ft. higher than the highest possible flood. The dam will thus be 15 ft. above the highest water.

The spillway is a concrete dam, 100 ft. high, 20 ft. wide on top, and 60 ft. wide at bottom, with a concrete foundation up to sea level, and extending 100 ft. down stream, to take the wear of the spillway. Where it crosses the diversion cut near the lock wall, this foundation may be 20 ft. or more deep. The first 1,000 ft. of the foundation next the lock will be up to sea level. The rest may be in steps to fit the rock ridge.

CONSTRUCTION.

This 1,000 ft. of spillway foundation next the locks will be the first work done. Then the sheet piling and grouting of the water-tight area under the dam should be placed, a temporary dam, about 10 ft. above low water, being previously built along the upstream toe of the earth dam on the line, G. G., to turn the water over the 1,000-ft. spillway foundation. After that, all work can proceed with no danger from floods. The locks, the dam and the head-wall across the site of the future lock-site can be built without the slightest danger of interruption from high water, a most important element of economy in such work, and one which, by the way, does not pertain to the Bohio site. The temporary dam will form part of the main dam which, under its protection, can be built exactly as desired.

While these works are being built, work on the spillway can be carried on. This will consist of a series of arches, the lower portions of the pillars of which could be put in with the foundation. The arches will be sufficiently large to pass all flood waters without over-topping the temporary dam. When the works are all completed, the arches can be closed by temporary covers, and then permanently filled with concrete. If desired, enough of them could be closed with valves to permit of the future emptying of the pool, but it is hard to conceive of any occasion for this.

Should the lock foundation prove too short for a flight of three locks, there is nothing to forbid a flight of two, with lifts of 50 and 55 ft. The existing prejudice against locks of greater lift than 35 ft. is based on the difficulties inherent in gates with miter sills. But if single straight floating caisson gates be used, there is nothing to prevent almost any reasonable lift. If a successful lock of 25-ft. lift be increased in proportion in all its parts, there is certainly nothing in physics to prevent its successful operation. The enormous lateral thrust of mitering gates requires, with high lifts, great masses of masonry not otherwise needed, so it is cheaper and much simpler in such cases to use single gates whose thrust is longitudinal with the walls. With such gates the complications of a miter sill are avoided, as no sill of any kind need be used, the steel gate simply resting with its full weight on a smooth steel surface securely anchored to the concrete. The limits of this paper prevent the details of the plan of locks and gates being given.

ESTIMATES.

The earth part of the dam would cost, as indicated above, about	$2,800,000
The sheet piling, about	300,000
The grouting, about	500,000

This assumes that the driving of the pipe will cost $1 a foot, which is ample, and that pipes 6 ft. apart will be necessary. It is also assumed that one-fifth the material is voids, and that the grouted zone is 6 ft. thick.

The locks will contain about 400,000 cu. yds. of concrete, which, at $10 a yd., would amount to	$4,000,000
Add, for gates and valves	500,000
And for contingencies	400,000
We have a total cost of	$4,900,000
The spillway and its foundation will contain about 350,000 cu. yds., which, at $10 a yd., would be	$3,500,000

The above estimates are based on a navigable depth of 40 ft. of water.

A liberal estimate for the breakwater at Colon is $5,000,000.

A straight cut from Limon Bay to the lock, 40 ft. deep and 300 ft. wide on the bottom, with side slopes of 1 vertical to 2 horizontal, at $1 per cu. yd., some of it being possibly rock, would cost about $25,000,000.

With this breakwater and straight entrance, the inner harbor could be omitted.

The necessary cut at Culebra cannot be exactly estimated from the facts on hand:

For a sea-level canal, 35 ft. deep, the chief engineer estimates	$125,000,000
For a 30-ft. level	86,000,000
For a 60-ft. level	59,500,000
At the proportional rate of decrease, a 90-ft. level should be about	44,000,000

Assuming this for our 100-ft. level, which would give 45 ft. in the cut, we would have for the total cost of the canal, from Colon to Pedro Miguel, a total of about $86,000,000; leaving of the present authorized $140,000,000, about $54,000,000, to build three locks on the Pacific side, and dig the canal between them. The total distance is ten miles, and the total excavation not more than 20,000,000 yds. 60 cts. a yd. should be ample for this, making $12,000,000.

The locks being all on rock foundation, $2,500,000, each should suffice, making $7,500,000, which should leave a balance for contingencies of $34,500,000, after the completion of a canal 5 ft. deeper and much wider than those on which comparative estimates are based.

TIME OF CONSTRUCTION.

In this, as in all other suggested plans the auxiliary works can all be readily completed before the Culebra cut. This plan, involving the least work on that cut, can therefore be completed the soonest. It should be noted that comparisons of time and cost of the various plans cannot be correctly based on the comparative amounts of excavation alone. As the cut is deepened, contingencies as to slides, congestion of plant, drainage, and increase in hardness and quantity of rock, must be allowed for. The removal of one yard of material below sea level for that type of canal, when the cost of pumping and the other above contingencies are counted, will doubtless amount to more than the cost of removing five or six yards for the 100-ft. level canal, and the proportionate delays would make the matter of time much worse for the sea level canal. It has been estimated that the latter can be completed in ten or twelve years. If so, the 100-ft. level should be finished in less than five years.

Under these circumstances it would appear proper to give the dam site at Gatun a much more thorough examination than has heretofore apparently been accorded it.

THE NEW BRITISH STANDARD RAIL SECTIONS.

British engineers have now followed the example of American engineers in endeavoring to reduce the unnecessary number and variation of rail sections to a uniform standard. The slight variations in sections of the same weight have little or no influence upon the wearing qualities of the rails, and are due mainly to the desire of individual engineers to embody their own ideas in the rails for their own particular roads. The American Society of Civil Engineers commenced its investigations into rail design and manufacture in 1873, and in 1890 appointed a committee to prepare designs for standard rail sections in an endeavor to reduce the number of existing sections to some standard of uniformity. In 1893 this committee made its report, which was adopted, and since then the sections recommended by the committee have come to be almost universally used. In England, the Engineering Standards Committee (representing the five leading engineering associations) appointed a committee on rails in 1901, and this was divided into a sub-committee on street railway rails and a sub-committee on railway rails. The report of the former was approved and issued in 1903, and the latter has since issued sections and specifications for bull-headed and T-rails. The bull-headed rails are not of much interest to engineers in this country, except that American mills sometimes roll such rails for foreign railways. There are nine standard sections varying by 5 lbs. from 60 to 100 lbs. per yd., and these have vertical sides to the heads, with radii of 12 ins. for both heads, and fishing angles of 20°. The top corner radius is ⅝-in. for rails of 60 to 80 lbs. per yd., and ½-in. for rails of 85 to 100 lbs. per yd. The distribution of metal varies with each weight of section, and has the following range:

	60-lb. rail, per ct.	100-lb. rail, per ct.
Head	46.4	50.12
Web	21.8	20.05
Base	31.8	29.83

There are 17 T-rail sections varying by 5 lbs. from 20 lbs. to 100 lbs. per yd. These sections are similar to those of the American standards in the following features: (1) The height and the width of base are equal; (2) the sides of the head are vertical, and (3) the top radius of head is 12 ins. They differ from the American sections in the following respects: (1) the distribution of metal is not uniform throughout the series; (2) the top corner radius is larger, and is not uniform; (3) the fishing angle is 14° instead of 13°; (4) the upper face of the base has not a uniform slope, but a much flatter slope beyond the bearing surface of the splice bar; (5) the sides of the web are vertical instead of curved; (6) the bottom corners of the base are sharp instead of rounded. The feature which most calls for criticism is the round top corner for the heavier rails; this radius being ¼-in. for sections of 20 to 40 lbs. per yd., 11-32 for sections of 45 to 60 lbs. per yd., and ⅜-in. for sections of 65 to 100 lbs. per yd. The distribution of the metal varies with each weight of section and has the following range:

	British, 20 lbs. per yd., per cent.	British, 100 lbs. per yd., per cent.	American, 40 to 100 lbs. per cent.
Head	47.05	45.19	42
Web	16.71	18.41	21
Base	36.24	36.40	37

The accompanying cut shows the comparative forms of the American and British 80-lb. sections, and their comparative dimensions are given in the accompanying table.

The principal parts of the specifications are given below, and it may be noted that those for the bull-headed rails call for similar chemical

	—80-lb. Rails.— American ins.	British ins.	—100-lb. Rails.— American ins.	British ins.
Height	5	5	5¾	5¾
Width of base	5	5	5¾	5¾
Width of head	2¼	2¼	2¾	2¾
Depth of head	1½	1½	1½	1½
Height of web	2½	2⅝	3⅛	3
Depth of base	⅞	1	1	1
Thickness of web	½	½	⅝	⅝
Radius, top of head	12	12	12	12
" top corner of head	⅜	⅜	⅜	⅜
" bottom corner of head	⅛	⅛	⅛	⅛
" top fillets	⅜	⅜	⅜	⅜
" bottom fillets	¾	¾	¾	¾
" corners of base	⅛	top ⅛	⅛	top ⅛
" sides of web	12"	Vert.	12"	Vert.
Edge of base	Vert.	Vert.	Vert.	Vert.
Fishing angles	13°	14°	13°	14°
Slope of base beyond fishing angle	....	1 to 10	....	1 to 10
Metal in head	42%	44.47%	42%	45.19%
" web	21%	18.71%	21%	18.41%
" base	37%	36.82%	37%	36.40%

composition except that the phosphorus is increased to 0.075% and the sulphur to 0.08%.

The steel for the rails shall be of the best quality made by the Bessemer, Siemens-Martin or other process, to be approved by the engineer (or by the purchaser).

The rails shall show on analysis that in chemical composition they conform to the following limits:

Carbon, 0.35 to 0.5%; manganese, 0.7 to 1%; silicon, max., 0.10%; phosphorus, max., 0.07%; sulphur, max., 0.07%.

The manufacturer shall make and furnish to the representative of the engineer (or the purchaser) carbon and phosphorus determinations of each cast.

A complete chemical analysis, representing the average of the other elements contained in the steel, shall be similarly given for each rolling. Such complete analysis shall be made from drillings taken from the rail or tensile test-piece or pieces. When the rolling exceeds 200 tons, an additional complete analysis shall be made for each 200 tons or part thereof.

Should the engineer desire to make independent chemical determinations, the necessary specimens and samples shall be furnished by the manufacturer. For this purpose not more than two rails in every hundred manufactured shall be selected by the engineer and drillings taken with a drill of 2 ins. diameter from the top of the head of the rail, unless otherwise specified by him, and if, upon being subjected to the specified tests, either fail to comply therewith, then all the rails in the blow of which the test pieces form a part may be rejected. In case of difference between the engineer (or between the purchaser) and the manufacturer, as to the accuracy of an analysis, either party shall have the right to have samples of the steel analysed by an independent metallurgist, to be mutually agreed upon. The expenses attendant upon such independent analysis shall be borne by the party adjudged to be in the wrong.

Each rail shall be made from an ingot not less than 12 ins. square at the smaller end and 14 ins. square at the larger end, which must be cogged down into blooms, and have sufficient crop then sheared from each end to ensure soundness.

A rolling margin of ½% under to ½% above the specified weight will be permitted, but the contract weight only will be paid for.

The whole of the rails shall be of uniform section throughout, true to templates, perfectly sound and straight, and free from splits, cracks, burrs, and defects of every kind.

A quantity of short lengths will be taken in such lengths and quantities as may be ordered by the engineer (or by the purchaser) provided that these short lengths are cut down from longer lengths found to be defective at the ends only, and that the total quantity taken does not exceed 7½% of the contract.

The rails shall be the specified length at a temperature of 60° F. No rail will be accepted which is more than $^{3}/_{16}$-in. above or below the length specified, whether for straight or curved lines.

When required by the engineer (or by the purchaser) rails are to be supplied from 1 to 6 ins. shorter than the normal specified lengths, and these special lengths are to have about one foot at each end painted with such colors as may be ordered.

The brand shall be rolled on the web of each rail to show that the rail is of British Standard Section and made under the conditions of this specification; the number of the "B. S." section (being the nominal weight of the rail in lbs. per yd.), the process by which the rails have been manufactured, the manufacturer's name, initials, or other recognized mark, and the month and year of manufacture shall also be rolled, in letters ¾-in. in size, on one side of the web of each rail, and the number of the cast or blow from which it has been rolled shall be stamped on the ends of each rail in ½-in. block figures.

From each cast a piece of rail shall be selected by the inspector and stamped with his mark and the number of the cast. From this a piece 5 ft. long shall be cut which shall be placed in a horizontal position, with the head uppermost, on two iron or steel supports resting on solid foundations, the upper surface of the supports being curved to a radius of 3 ins.; this sample may be taken from a crop end. The test shall comprise one blow, delivered midway between the bearings, from a falling weight, the striking face of which shall be curved to a radius of not more than 5 ins. In addition to the above test, the inspector shall select one finished rail from every 200 offered and a piece 5 ft. in length cut from this rail shall be similarly tested as specified above.

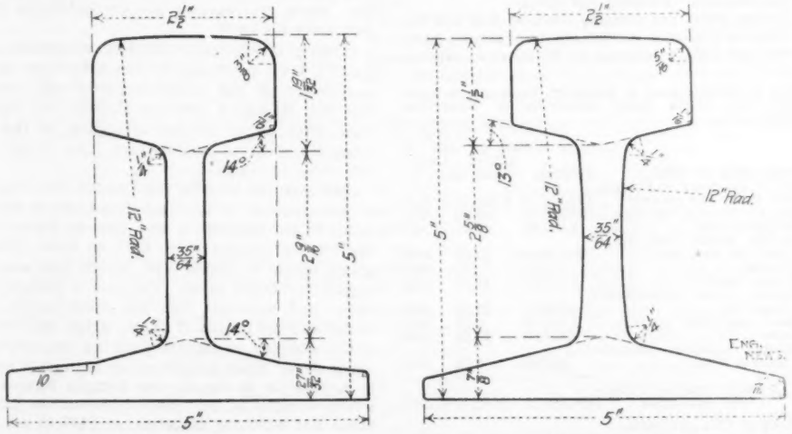
(The weight of hammer is 2,240 lbs. for rails of 60 to 100 lbs. per yd. The distance between centers of bearings is 3 ft. for rails up to 65 lbs., and 3 ft. 6 ins. for rails of 70 lbs. and over per yd. The fall is 20 ft. for 60 to 75-lb. rails, 22 ft. for 80-lb., 24 ft. for 85-lb., 26 ft. for 90-lb., 28 ft. for 95-lb. and 30 ft. for 100-lb. rails.—Editor Engineering News.)

Should any rail show fracture under the falling weight test, the entire cast from which it was selected shall be rejected.

From each 100 tons of rails the manufacturer shall (if required by the representative of the engineer or of the purchaser) cut a test piece from any rail selected as a sample rail; such test piece to be stamped to correspond with the sample rail. It shall then be placed in a testing machine of approved pattern, and shall show an ultimate tensile strength equivalent to not less than 40 tons per sq. in. nor more than 48 tons per sq. in., with an elongation of not less than 15% upon the standard test piece (0.564 in. or 0.798-in. diameter, equivalent to ¼ or ½ sq. in. sectional area). Should the test piece fail to fulfil these conditions, the representative of the engineer (or of the purchaser) may require the manufacturer to test two other rails from the same cast in the same manner, and the acceptance or rejection of the cast shall be decided by the result of the three tests, so that if two of the three rails selected shall fail to comply with the test the entire cast will be rejected.

Should the engineer (or the purchaser) desire to have independent tests made, the manufacturer shall provide the necessary test pieces (two for every 200 tons), properly shaped and prepared as described on page ——.

The holes for fishbolts must be drilled through the web from the solid at each end of the rails, of the sizes and in the position shown on the drawing to be supplied by the engineer (or the purchaser). These holes must be clean and square with the web, without burrs on either side, and will be checked with the gages to be furnished to the manufacturer by the engineer (or by the purchaser). Should any of the holes vary from the correct size or position more than $^{1}/_{32}$-in. the rails in question will be liable to rejection.



BRITISH AND AMERICAN STANDARD RAIL SECTIONS; 80-LB. RAILS.

SOME RECORDS OF MAINTENANCE-OF-WAY EXPENSES ON AMERICAN RAILWAYS.

In all accounting for engineering construction and maintenance work, it is important that unit costs shall be determined or made obtainable, but a class of work in which this feature is to a great degree neglected is that of railway maintenance-of-way. This has been shown very strongly as the result of a recent investigation of this subject, and we present herewith some of the information obtained, while in another column we have discussed the general subject. The annual reports of railway companies form the most available source of information, but these give merely totals and lump sums, from which no definite comparisons or deductions can be made. Beyond these, there is little information to be had, and division reports as a rule do not enter into greater detail. As a rule, the reports give the total expenditures under a certain limited number of headings, and in rare cases their relation to the operating expenses are shown. The Hocking Valley Ry. is an example of this, and Table I. shows the percentages for the years 1903 and 1904 (omitting the actual sums). It should be explained that the percentage on this road (10%) is lower than on most roads:

TABLE I. Ratio of Maintenance Expenses to Operating Expenses—Hocking Valley Ry.

	Percentage of Operating Expenses 1903.	1904.
Repairs of roadway	4.46	4.84
Renewals of rails	0.93	1.15
Renewals of ties	1.49	1.69
Repairs and renewals of bridges and culverts	1.36	1.09
Repairs and renewals of fences, road crossings, signs and cattle guards	0.25	0.20
Repairs and renewals of buildings and fixtures	1.37	1.23
Repairs and renewals of docks and wharves	0.07	0.03
Repairs and renewals of telegraph	0.04	0.05
Stationery and printing	0.01	0.01
Other expenses	0.02	0.02
Total percentage of operating expenses	10.02	10.31

The Illinois Central Ry. and the Atchison, Topeka & Santa Fe Ry. give in their reports tables of the average annual cost of maintenance-of-way and structures per mile of line, but while this is interesting in default of anything better it must be remembered that the amount of work varies considerably each year, while the length of road remains practicably constant, so that a low cost per mile may be due to a small amount of work rather than to an actual low cost of the work. The figures for these two roads are given in Table II.

TABLE II.—Annual Expenditures for Maintenance-of-Way and Structures per Mile of Road.

	Illinois Central Ry.	A. T. & S. F. Ry.
1897	1,148	975
1898	1,127	1,194
1899	1,167	1,090
1900	1,448	866
1901	1,390	824
1902	1,321	782
1903	1,376	1,168
1904	1,308	1,121

Following this a little further we have taken the items of rail renewals and tie renewals, which are two important items of maintenance-of-way expenses, and calculated the average cost per mile of road and per mile of track (including sidings) for a number of railways. These again are of some general interest, but their value is materially decreased from the fact that the number of miles on which work was actually done cannot be ascertained. However, the figures are given in Table III., and it will be noted that on 16 of these 20 railways the cost of tie renewals was more than that for rail renewals, the opposite being the case only on the Buffalo, Rochester & Pittsburg Ry., the Norfolk & Western Ry., the Wabash Ry. and the Cincinnati Southern Ry.

TABLE III.—Annual Expenditures for Rail and Tie Renewals in Dollars.

	Rail renewals, —per mile.— Of line.	Of track.	Tie renewals, —per mile.— Of line.	Of track.
N. Y., N. H. & H.	47	23	290	144
Erie	90	70	162	122
Lehigh Valley	124	60	433	225
Del., Lack. & West.	183	73	349	138
N. Y. Central	148	70	322	150
N. Y., O. & West.	80	62	246	190
Buffalo, R. & P.	241	143	136	80
Phila. & Read	166	68	389	160
Balt. & Ohio	104	60	126	73
Norfolk & Western	202	143	196	140
Ches. & Ohio	127	87	141	97
C. C. C. & St. Louis	45	29	133	89
Wabash	140	100	130	100
Cincinnati So.	206	135	104	68
Hocking Valley	171	96	260	146
Chicago & E. Ill.	30	19	129	74
Chi., Ind. & L.	106	80	205	155
Chicago & N. W.	34	24	95	66
Chi., Mil. & St. P.	97	71	126	92
A. T. & S. F.	127	100	147	118
Maximum	241	143	433	225
Minimum	30	19	95	66

PENNSYLVANIA LINES.—One of the maintenance-of-way officers kindly undertook to procure information as to itemized expenses, but finally stated that he had not been successful in getting from the division officers, when he asked for the information, any satisfactory replies. The reasons for this are as follows: 1. The prime object for division in the accounts is to furnish the auditor with the knowledge he desires, and the subdivision

THE UNITED ENGINEERING BUILDING has been contracted for, as noted in our Construction News supplement of last week. The Building Committee, of which Mr. T. C. Martin is President, has awarded the general contract for the building to Wells Bros. Co., 160 Fifth Ave., for $795,000. This does not include the steam heating plant, electric wiring, etc. The site for the building, on West 39th St., has been excavated, and construction will begin at once. October, 1906, is named as the date of completion.

ANOTHER TRIP IN SEARCH OF THE NORTH POLE was begun July 16 by Lieut. Robert E. Peary in command of the "Roosevelt," a ship especially constructed for the purpose. Peary expects to be frozen up about Sept. 15 off the north shore of Grant Land, latitude 83°. This will leave 420 nautical miles to travel to reach the pole; and early in February, as soon as there is sufficient light, a northward dash will be made with 150 dogs and 25 sleds.

FURTHER CRIMINAL PROSECUTIONS AT PHILADELPHIA are advised by the Hon. Elihu Root, who has been serving as special council to Mayor Weaver, but must terminate that and other private services to re-enter President Roosevelt's cabinet. In a letter dated July 15 Mr. Root states that it appears from correspondence laid before him that Mayor Weaver has "caused the evidence of grave crimes by a number of powerful and important persons in the city of Philadelphia to be laid before the District Attorney," and since the latter holds that the mayor should initiate the prosecution in these, as in the earlier criminal proceedings, Mr. Root advises the mayor to cause the apprehension of these unnamed offenders before a city magistrate. Speaking of further prosecutions, Mr. Root says:

> There is more at stake here than the mere punishment of isolated offenses. There is the question whether your city shall continue to be governed by criminals or shall take its place on the list of American cities capable of honest self-government. To secure the right solution of this question you cannot omit any proper and lawful effort.

In concluding his letter Mr. Root said:

> I have taken very great interest in the cases because I have acquired absolute confidence in the sincerity of your purpose and in your pluck and persistency, and I have a strong desire that the city of Philadelphia, whose history and good name are so dear to every American, shall be relieved from the stain which a corrupt and criminal combination, masquerading under the name of Republicans, has put upon her.

AN ELEVATOR FELL SEVEN STORIES or more in the Land and Title Building, Philadelphia, on July 18. Mr. John C. Bell, District Attorney of Philadelphia, had one leg broken and the ankle of the other leg sprained; a second passenger had several bones in both feet broken and a knee cap and thigh bone splintered; a third passenger suffered numerous contusions and possibly concussion of the brain; the elevator operator escaped with a cut chin and lip. The officials in charge of the building state that the elevator merely got beyond control of the operator and descended with "more than its accustomed speed." One of the passengers claims that the cable wheel at the top of the shaft gave way and, with the cable, fell on the roof of the car, crushing it in. This the officials deny. The reported breaking of glass in the elevator during its fall would seem to indicate something beyond a mere acceleration of speed. According to Mr. Alonzo Dalton, Chief Engineer and Superintendent of the building, the elevator was equipped with a speed governor operating safety dogs and also with a Cruikshank safety device. Mr. Dalton is quoted by the "Public Ledger" as follows:

> You see this car did not fall. It was a runaway car, and had it fallen and acquired an unusual rate of speed the devices, with which it was equipped, would have worked and saved all this trouble.

Elevator inspection at Philadelphia is reported as having been confined chiefly to new elevators during the past two years, most of the elevator inspectors having been ordered to inspect fire escapes instead. A city ordinance passed April 6, 1900, requires the Bureau of Building Inspection to inspect "all power-driven elevators" at least once in three months, regardless of inspections by casualty companies; the ordinance also authorizes the chief of the above-named bureau to order air cushions for passenger elevators when deemed necessary by him. It appears that the elevator in question was provided with neither air cushion or springs at the base of the shaft, although the building in which it is located is at least 14 stories high.

PERSONALS.

Mr. Marcey H. Carpenter, of Wingate, Miss., has been appointed Lumber Inspector for the Isthmian Canal Commission.

Mr. J. B. Nichols has been appointed City Engineer of Lorain, O., to succeed Mr. Charles S. Ferguson, who has resigned.

Mr. J. G. Holcombe, a civil engineer of New York City, has been appointed Division Engineer for the Panama Canal.

Mr. Jackson Smith, of South Carolina, has been appointed Assistant to Chief Engineer Stevens of the Isthmian Canal Commission.

Mr. James Maclarity, of West Hoboken, N. J., has been appointed Supervisor of air compressors for the Isthmian Canal Commission.

Mr. J. W. Johnson has been appointed Superintendent of the municipal water-works of Oklahoma City, Okla., to succeed Mr. J. W. Johnson.

Mr. O. C. Roedder, N. A., has removed his consulting engineering offices from 18 Amalienst, Karlsruhe, Germany, to 38 Kianprechtst, that city.

Mr. C. W. Osterhold, of Yonkers, N. Y., has been appointed Superintendent of Mines on the Isthmus of Panama for the Isthmian Canal Commission.

Mr. P. H. Irwin has been appointed Consulting Engineer for the Baltimore & Ohio R. R., with headquarters at Baltimore, Md., vice Mr. David Lee, deceased.

Mr. A. S. More has been appointed Engineer Maintenance of Way of the Michigan Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry., vice Mr. A. L. Kuehn, transferred.

Mr. Leon F. Rittenhouse, of Brooklyn, N. Y., for some time an Instructor at Armour Institute, Chicago, has been elected to the chair of engineering at Harverford College.

Mr. Geo. Myers has been appointed City Engineer of Iola, Kan. Mr. Myers was connected formerly with the Atchison, Topeka & Santa Fe Ry., with headquarters at Topeka, Kan.

Mr. C. B. Clark has been appointed Engineer of Maintenance of Way of Cleveland, Cincinnati, Chicago & St. Louis Ry. and the Peoria & Eastern Ry., with headquarters at Cincinnati, O.

Mr. M. J. Butler, until recently Assistant Chief Engineer of the Canadian Transcontinental Ry. Commission, has been appointed Deputy Minister of Railways and Chief Engineer of Canals for the Dominion of Canada.

Mr. Charles N. McKergow, of Montreal, Que., has been appointed to a position in the Mechanical Engineering Department of the University of Virginia. Mr. McKergow is a graduate of McGill University.

Mr. C. W. Raynor, Assoc. M. Am. Soc. C. E., has opened an office as a Consulting Engineer at 407 Jackson Block, Denver, Colo. He will make a specialty of city and country bridges for highway traffic.

Mr. M. W. Thomas, until recently Manager of the Westinghouse Electric & Manufacturing Co.'s office in New Orleans, has been appointed Manager of the Allis-Chalmers Co.'s District Office at Atlanta, Ga.

Mr. A. H. Whiteside, for some time Manager of the Allis-Chalmers Co.'s District Office at Atlanta, Ga., has been transferred to the Philadelphia District Office, where he succeeds as Manager, Mr. W. A. Wood, resigned.

Mr. James W. Hyson, of Melrose, Mass., and Miss Edna L. Pomeroy were married July 8 at the home of the bride in Chester, Mass. Mr. Hyson is a civil engineer engaged on construction work on the Boston & Albany R. R.

Mr. George R. Wadsworth has resigned his position as Resident Engineer of the New York Central Ry. to accept that of assistant to the construction manager of J. G. White & Co., contractors, with office at 43 Exchange Place, New York City.

Mr. Francis W. Blackford, M. Am. Soc. C. E., for the past four years Chief Engineer of the Cerro de Pasco Railway & Mining Co., of Cerro de Pasco, Peru, S. A., is now engaged in professional work in Mexico, with headquarters at Saltillo, State of Coahuila.

Mr. Paul Voorhees, Assoc. M. Am. Soc. C. E., has resigned his position as Engineer for The Buffalo & Susquehanna Iron Co., Buffalo, N. Y., and has accepted a position as Assistant Engineer for the Philadelphia & Reading Ry., with headquarters at Harrisburg, Pa.

Mr. W. J. Buckley has been appointed Manager of the Allis-Chalmers Co.'s District Office at St. Louis, and Mr. H. P. Hill, whom he succeeds, goes to the Salt Lake City District Office, where he will devote himself to his specialty, the electrical features of the company's business.

Mr. T. P. Shonts, Chairman of the Isthmian Canal Commission; General O. H. Ernst, a member of the Commission; Mr. John F. Stevens, the newly appointed Chief Engineer of the Canal, and Mr. David Ross, General Purchasing Agent for the Canal Commission, will sail July 20 for Panama.

Mr. Isham Randolph, M. Am. Soc. C. E., Chief Engineer of the Chicago Drainage Canal and the Chicago Sanitary District, has been given three months' leave of absence in consequence of his appointment by President Roosevelt as a member of the board of consulting engineers for the Panama Canal.

Mr. Chas. A. Bowman, for the past ten years with the Metropolitan Water Board as Division Engineer in the Reservoir Department at Clinton, Mass., has resigned that position and has entered the engineering firm of Morrison & Farrington, Inc., General Engineers, Dillaye Memorial Building, Syracuse, N. Y.

Mr. John E. Greiner has been appointed Assistant Chief Engineer of the Baltimore & Ohio R. R., with headquarters at Baltimore, Md., succeeding Mr. P. H. Irwin. He will perform the duties of Engineer of Bridges and Buildings, and such other duties as may be assigned to him from time to time by the Chief Engineer.

Mr. R. T. Fox has been appointed Superintendent of Street Cleaning for the city of Chicago. He was for some time connected with the New York Street Cleaning Department, and for a year past has been in charge of the organization and management of the street cleaning system inaugurated by Chicago merchants for the cleaning of the down-town district, owing to the city's failure to have the work done.

Mr. Louis D. Fouquet, who has been engaged during the past year on the construction of the masonry and superstructure of a four-track Scherzer rolling lift bridge at Saugatuck, Conn., on the main line N. Y., N. H. & H. R. R., under Mr. H. B. Seaman, A. E. C., has been transferred to New Rochelle, N. Y., under Mr. R. M. Berrian, Assistant Engineer of Construction on the Harlem River improvement work for the same road.

Mr. C. M. James has been appointed Acting Engineer of Roadway on the Atlantic Coast Line R. R., at Wilmington, N. C., vice Mr. George B. Huske, resigned on account of ill health. Mr. James was formerly Assistant Engineer of the Baltimore & Ohio R. R., and more recently, Assistant Engineer on the Atlantic Coast Line. In our last week's issue the name of the newly appointed Acting Engineer of Roadway was incorrectly given as Mr. C. M. Jones.

Obituary.

Francis Boyle, a retired civil engineer, died July 11, at his home in New York City, from gas poisoning.

B. A. Pope, for a number of years Assistant Engineer to the Board of Mississippi Levee Commissioners died recently at Castalian Springs, Miss.

George E. Carter, for the past six years Superintendent of the Water Department of Chicopee, Mass., died suddenly July 9 from heart failure. He was 41 years old.

Dean C. Warren, a civil engineer in the employ of the New York Rapid Transit Commission as an Assistant Engineer in the New York-Brooklyn tunnel, died July 6, at his home 149 Amity St., Brooklyn, from blood poisoning. Mr. Warren was but a young man, a graduate of Norwich University, Northfield, Vt., in the class of 1893. He had, previously to coming to New York, been long in the employ of the Metropolitan Sewage Commission and of the Massachusetts Highway Commission, where he had had responsible charge of important work. In connection with his New York work his unusual ability was receiving due recognition. A widow survives. The interment was at the Vermont home of the deceased.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Annual convention, Portland, Ore., Aug. 21-4. Secretary, Tom. Richardson, Portland, Ore.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 23 to 25, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B & Q. Ry., Beardstown, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 18 to 20. Annual meetng at Bethlehem, Pa. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

NATIONAL IRRIGATION CONGRESS.—The thirteenth annual gathering will be held at Portland, Ore., Aug. 21 to 24. The Congress will be divided into sections, some of which have presiding officers as follows: Engineering, F. H. Newell, Chief Engineer U. S. Reclamation Service; Forestry, Gifford Pinchot, Chief of the U. S. Bureau of Forestry; Climatology, H. E. Williams, U. S. Weather Bureau; Production by Irrigation, Dr. A. C. True, Director U. S. Experiment Stations; all of Washington, D. C. During the Congress there will be a gathering of the engineers of the U. S. Reclamation Service. The leading officers of the Congress will be: President, Gov. Geo. C. Pardee, of California; Chairman Executive Committee, C. B. Boothe, Los Angeles, Cal.; Secretary, Tom. Richardson, Portland, Ore.

ENGINEERING NEWS

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THE PANAMA CANAL: SOME SERIOUS OBJECTIONS TO THE SEA LEVEL PLAN.

By Major Cassius E. Gillette.*

Perhaps the most important engineering problem that ever required solution is that of the plan for the canal across the Isthmus of Panama. The cost involved is almost beyond the grasp of the imagination. Even the difference between the least and the most expensive plans that have received serious consideration is equal to the cost of almost any one of the greatest engineering works of the world. Under these circumstances any plan that gives any prospect of success and economy should be carefully considered.

In general, that plan for any engineering work is best which accomplishes the desired object at the least total cost.

In the case under consideration the object is the passing of the present and future commerce of the world with certainty, safety and reasonable promptness. The last consideration, however, is of limited importance, since the voyages concerned will be mostly measured by thousands of miles in distance and by weeks in time. Hence, whether it takes six hours or twelve, to pass the canal is a matter of small moment.

The cost of the canal is made up of the first cost, the cost of operation and maintenance, and the cost of enlargement. The cost of enlargement is a very important matter, as can be seen by the history of existing canals. The old state canals of Ohio and Pennsylvania, once great arteries of commerce, are now almost useless on account of their small size. The Erie canal has been once enlarged, and $101,000,000 is to be spent in rebuilding it to suit 1,000-ton barges.

The original "Soo" lock, built about fifty years ago, has been twice augmented by a new lock, each much larger than its predecessor. The Suez canal has been enlarged once, and is now too small.

In 1854 the United States nearly completed a convention with Granada to build a canal at Panama. Had one been built of an appropriate size for that date and not enlarged, large ships would to-day doubtless be going around Cape Horn in successful competition with boats small enough to go through the canal.

Some one has said that the best pavement for American cities is the one that can be most easily dug up. Similarly, it might almost be said that the best Isthmian canal is the one most easily rebuilt on a larger scale.

Most reports and writings on the subject seem to take it for granted that a sea level canal is the only one that will fulfill this important condition, but such a conclusion is by no means borne out by the facts.

Another seemingly off-hand conclusion that has been announced in nearly if not quite all of the reports of commissions and technical committees on the subject, is that a dam is not practicable at any site north of Bohio. Up to quite recently this pronouncement never appears to have been based on any borings, or other ascertained facts. The Chief Engineer and the Engineering Committee of the recent Commission came to the same conclusion as regards the proposed site at Gatun, this conclusion apparently being based on two borings.

The advantages of a canal involving a high dam at Gatun,* are so great in the controlling elements of cost, time of construction, serviceableness and ease of enlargement, that the discovery of the best location and the devising of a dam that will successfully fit that location, are problems worthy of the most thorough study and research.

To point out these relative advantages, and to suggest a possible solution, the following article has been prepared:

The map (Fig. 1) gives the principal localities necessary to the discussion. It will be noted that the upper Chagres River is on the east of the canal line, while the mouth is on the west. This crossing of the river by the canal introduces, perhaps, the most serious element into the problem. The river flow must be taken into the canal, or the stream must be kept on the east side throughout, since it is wholly impracticable to carry the canal across the river on a viaduct, as has been done in the past with small canals crossing moderate streams.

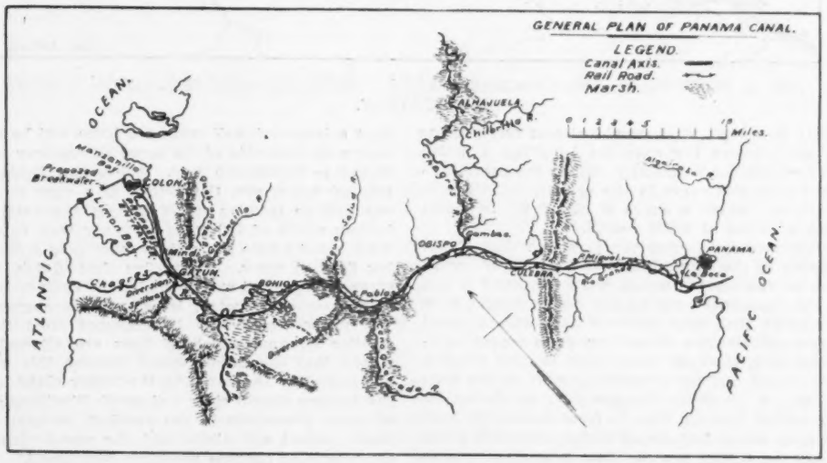

FIG. 1. GENERAL MAP OF THE PANAMA CANAL.

Another factor of vast importance, which, however, has received scant consideration in the past is that of sediment. This has generally been dismissed with the statement that the upper Chagres is not a silt bearing stream. The writer has known an ordinary canal, 50 ft. wide and 5 ft. deep, to be filled to the surface with mud in a few hours by a "clear water" brook that one could step across in ordinary stages. It does not seem that this subject of sediment deposit has been given the consideration in Panama canal plans that its importance warrants.

The upper Chagres is doubtless a clear-water stream at low stages, but how much sediment it actually carries in floods seems never to have been measured. Its condition at present, too, is no guarantee of what it will be when the canal is opened. At present the tropical jungle is so thick that no matter how hard it rains the water only reaches the ground gradually, and flows off slowly through the mass of ground verdure, so that it can cause little or no erosion. When the French company had a large force at work, a large area of this jungle was cleared and put under cultivation to raise supplies for the workmen. The same thing will occur again when the canal force is augmented, and it may be expected to continue indefinitely, since passing ships and regular trade will doubtless furnish a market for all the bananas that can be raised as far up every stream as a canoe can be pushed. The country is made up of very steep slopes of volcanic soil, easily eroded, and every stream that flows into the canal will become a menace to it. The evil could, of course, be lessened by buying the land and forbidding agriculture, but this would be expensive, and would lose to the world the agriculture of a very rich region, whose products would probably be quite valuable to passing ships.

The map (Fig. 2), shows that portion of the canal line from Culebra to San Pablo a distance of about 15 miles, where the sediment question is the most important. The valley here is narrow, and the present river surface at Gamboa is about 55 ft. above sea level.

The problem of disposing of the sediment of all these streams, if a sea level canal be adopted, is a serious one. The canal must occupy the bottom of the narrow valley and its water surface, if on the sea level plan, must be no less than 55 ft. below the present river surface, its bottom 35 or 40 ft. lower still, while its banks are of easily eroded material. The sediment from even the smaller streams cannot be neglected. The Mandigo River, for instance, seems to have a drainage area of ten or fifteen square miles, and as it is on the Atlantic side of the divide, it must be subject at times to torrential floods.

The sediment question has generally been dismissed with the simple proposition to dredge the mud as it is deposited, but this, in addition to the

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*This location, the writer believes, was first suggested by Mr. C. D. Ward, M. Am. Soc. C. E., in 1879.

very large perpetual cost, would, at least in the above section, require a canal practically of double width—one width for traffic and the other for dredges and scows. (It is assumed that the estimates for a sea level canal have not been based on a width great enough in deep cuts for large ships to pass each other, except at special points).

Another element of the problem that does not seem to have been given the consideration it warrants, is the difficulty of large ships navigating the present Atlantic end of the canal in the high winds that prevail in that vicinity. The present entrance, which forms a part of all plans that have been considered or recommended, is especially dangerous. A large ship, trying to pass the sharp reverse curve necessary to get into the canal in a high wind, would almost surely come to grief unless the entrance be given a width great enough to practically abolish the curve. Another very bad curve in the present canal line is at Gatun, where a curve of about 45° is shown with a radius of 3,000 meters.

The writer ventures the assertion that if the velocity of the high winds and the radii of curvature of the above curves, were furnished a few of the captains of our largest ocean vessels, with a request that they indicate how wide a canal they would require at such points to render navigation safe, their opinions would call for a width that would add an astonishing sum to the estimates. A perfectly straight cut, as shown by the dotted line on Fig. 1, from Gatun to deep water in Limon bay, would go far to remedy these things, as a ship can navigate a straight course in a comparatively high wind, especially one directly ahead or astern, as would be the case with the cut suggested. Further up the river are many other bad curves, but they are somewhat less objectionable, as the wind is less, and the forest gives some protection. But even without wind they add greatly to the difficulties of navigating large ships.

Bearing in mind the above considerations, let us now compare the advantages and disadvantages of various general plans for the solution of the problem:

THE SEA LEVEL CANAL.

GENERAL DESCRIPTION.—The plan involves a dam at Gamboa rising to a height of 200 ft. above tide, with a masonry core wall down to bed rock, the main dam to be built from the spoil from the Culebra cut. This dam is to act as a regulator for the Chagres River, the flow to be discharged at a uniform rate, either into the canal by suitable waste gates, or into a diversion channel by these gates, or by a tunnel 3.4 miles long, into the Gatuncillo, thence into the diversion channel further down stream.

COST.—The estimated cost of this canal, 150 ft. wide at bottom, and 35 ft. deep, is $230,475,725, and the time required to build it, from ten to twelve years.

OPERATION AND MAINTENANCE. — The sediment of the upper Chagres is disposed of in this plan by the above high dam, but that from the other tributaries is not. Those on the left bank of the river below San Pablo can be easily kept out by a continuous levee, as the flat land is wide. On the other side the canal at several places is quite close to the hills, and much erosion of the levee on this side, with frequent breaks, may be expected. This is especially true of the long diversion proposed for the Gatuncillo. The channel planned for this is large enough for the water, but the Gatuncillo in flood carries a very large proportion of mud, even now, and the narrow, deep channel will probably soon fill up so

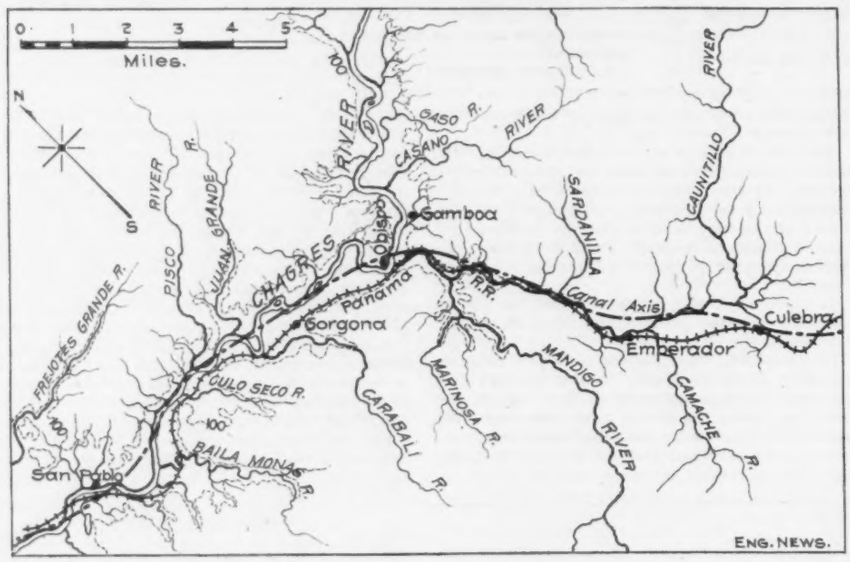


FIG. 2. PORTION OF THE CHAGRES VALLEY WHERE SEDIMENT DEPOSITION IS MOST IMPORTANT.

that a long and well-protected levee will be necessary on that side of the canal all the way from Gatun to Manzanillo Bay. Above San Pablo, as pointed out above, the matter is a very serious one and no solution for it has yet appeared. A bottom width of 150 ft. is certainly very narrow for a canal where large ships must pass a dredging fleet at work. Thirty-five feet depth, too, gives a very small margin under the keels of large ships now constructed, let alone future growth, and many floods may be expected from these smaller streams which, if they are allowed to empty into the canal, would destroy this margin and close the canal to the larger ships until the dredges should clear a channel. The likelihood of ships grounding in the crooked channel has been pointed out above and the speed through the restricted channel would be very small.

The ordinary time of transit, and the delays due to blockade from accident, are probably both greater in a sea level canal of the width, depth and curvature involved in the above estimate, than in a canal provided with locks, but with otherwise suitable dimensions.

EASE OF ENLARGEMENT.—As stated above, it has generally been considered that the enlargement of a sea level canal is an easy matter, but when it is remembered that this will involve the subaqueous removal of rock for a width of something more than 150 ft. for a distance of from 15 to 20 miles, the work beginning at 35 ft. below low water, and being carried down to 40 or 45 ft., whatever is determined on as the new depth, it will be seen that the expense involved is a tremendous one. Moreover, when such deepening is demanded, ships will be using the canal, loaded to the maximum permissible draft, and many of them are likely to be sunk by striking rocks scattered by the blasting.

At least a portion of the fourteen miles of canal through Culebra cut is to be held between masonry walls to prevent the water disintegrating the soluble clay in the banks. To tear out at least one of these walls and replace it subaqueously will be no easy problem. In other words this part of the canal will surely have to be made large enough in the first place, and anything like a liberal estimate of future demands will call for an appalling increase in the required funds.

The proposed 30-ft. tunnel spillway, 3.4 miles long, is a rather dubious proposition. The bottom of this tunnel is to be 68 ft. below the crest of the Gamboa dam. It will probably be inaccessible except once a year for a short period. Water is to flow through it at the rate of 20 ft. per second. Erosion may be excessive, and repairs will be difficult. It passes through a country that is badly shattered, broken rock and soft material being mixed without much system. An earthquake or other accident might block the tunnel. Should the dam be overtopped, the down-stream backing would melt away, the masonry core break, and the whole mass be rushed down the valley to the complete ruin of the canal. The only safe plan is to provide a spillway of ample dimensions. The spillway provided at Bohio for a discharge not greatly in excess of that at Gamboa, with a regulating lake of about the same size, is 2,000 ft. long, with a maximum depth of 7 ft. If this, or a shorter spillway, is provided at Gamboa, at a height of 200 ft., the dam must be raised 7 ft. or more.

The utility of the masonry core wall to the dam is not patent. It really converts the dam essentially from an earth and rock structure into an inefficient masonry one. By stopping all seepage of water, the rock and clay fill above the dam becomes thoroughly saturated, and the large proportion of soluble clay in its composition would make it, so far as pressure is concerned, a fluid heavier than water, with a correspondingly increased thrust. The down-stream fill would be completely drained, and could not be brought to an efficient bearing until it had been compressed by the pressure of the masonry dam against it, which would involve a yielding of the structure. The conditions then are highly favorable for a rupture of the core. The advocates of a similar structure at Bohio claim it gives no added strength to the dam, but saves water that would otherwise percolate through and underneath the dam. Granting for the moment that this may be true, there is no apparent need of such action at Gamboa, as the omission of the masonry core would only cause the addition to the canal of a moderate amount of filtered water.

THIRTY-FOOT LEVEL CANAL.

GENERAL DESCRIPTION.—(All canals involving locks will have a short portion of sea level canal between the terminal lock at each end and the ocean.)

The 30-ft. level involves either a canal with built-up banks, or a dam at each lock forming a pool of moderate size. The former is wholly out of the question, as the banks would constantly be liable to rupture from burrowing animals or malicious persons, so that the navigation provided would not be reliable. The small pools provided by the plan with dams would not control the flow of the Chagres, but would make its diversion more difficult, while in the narrow parts of the upper valley the canal would be constantly menaced by the sediment from all the smaller streams.

A 30-ft. canal has been proposed in which the Chagres flow is to be divided at Obispo, and one-half of it sent in each direction in the canal itself; 30-ft. dams being provided at Mindi on the Atlantic side, and near La Boca on the Pacific.

It is doubtful if sites for these dams can be found that will not require them to be of excessive length—practically long levees. The trouble with taking one-half the flood stages of the Chagres into the canal is that at Obispo there would be a fall of 25 ft., and the swift current there, and at all curves below, would erode the banks and fill up the canal. In other words, the floods would make a river of the canal, with caving banks, deep eddies and shoal "cross-overs." This river would be somewhat regulated by the Gamboa and Alhajuela dams proposed, but there would still be strong and variable currents.

To protect the banks against this would involve an enormous expense. Assuming this to be done, the trouble with sediment would remain. The plan provides for permanent dredging at the "forks" at Obispo, where a small triangular pool is provided. The velocity through this in floods would be so great that only the coarsest detritus

would be deposited; the rest would have to be dredged out at many points below. This would require a canal of great width down to the pools, and a great continuous expense for dredging.

COST.—The estimated cost of a 30-ft. level canal is given by the Chief Engineer as $194,213,-40[illegible]. This is based on a lock and spillway at Bohio, and a controlling dam at Gamboa.

The 30-ft. canal with the divided flow of the Chagres is estimated by its projector at less than $150,000,000.

One great advantage that pertains to the 30-ft. level canal, and to all plans involving a navigable lake above the dam, is that the future enlargement through the Culebra cut can be provided for by simply raising the dam and spillway and building extra locks of the required dimensions.

SIXTY-FOOT LEVEL CANAL.

GENERAL DESCRIPTION.—This involves a dam, locks, and spillway at Bohio, and a controlling dam at Gamboa.

COST.—This is put at $178,013,406.

OPERATION AND MAINTENANCE. — The dangers and difficulties pointed out above in connection with the high Gamboa dam, pertain to this canal. It would lessen, but not remove the sediment troubles above San Pablo. It would involve two large dams instead of one. It would

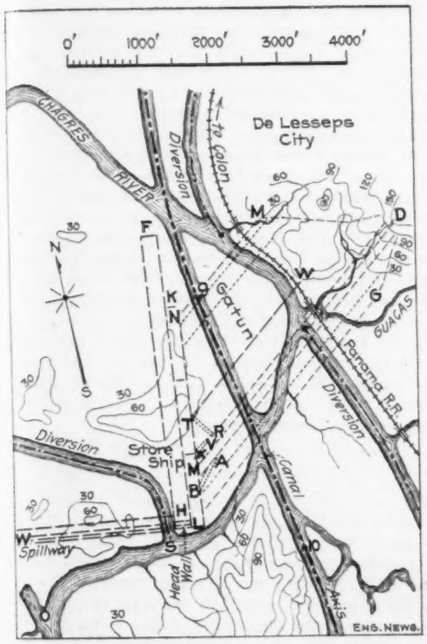


Fig. 3. Plan of Proposed Dam at Gatun.

provide only a comparatively small lake for regulating the Chagres floods, making inconvenient fluctuations, with added dangers of overtopping the dam. The difficulties of construction would be great. It is very hazardous work to attempt to construct an earth dam, with or without a masonry core, in a narrow valley, without first diverting the water. To construct a temporary spillway at the low water level would be an expensive operation at the Gigante site, and a risky one at the lock pit. When completed there would still remain 18 miles of sea level canal to construct below the dam, with the difficulties in the diversion of the Gatuncillo and other small streams on the east of the canal.

The approved plans of this dam involve a masonry core, put in by the pneumatic caisson process, and extending down to bed-rock, about 163 ft. below low tide, or, what is about the same thing, below local low water in the river. The expense of this would be enormous, and its feasibility very doubtful.

In a paper on the subject (See "Transactions, Am. Soc. C. E.," Vol. 48), the late Mr. George S. Morison demonstrated that this core is not necessary to limit seepage. It certainly is not needed for anything else.

85-FT. AND 97.5-FT. LEVEL CANALS.

These have been proposed, with a dam, spillway and locks, at Bohio, with or without a water supply dam at Alhajuela. For the 85-ft. level, the dam at Gamboa, to arrest sediment as well as store water, would probably be necessary, instead of the Alhajuela dam. The pool of the 97.5-ft. level would extend far enough up the Chagres above Obispo to form an efficient settling basin. The 85-ft. canal would not be troubled with the sediment from the smaller streams so much as the 60-ft. level; and the 97.5-ft. level would be affected still less. The pond, however, should extend a mile or so up each stream that flows into the Chagres between Emperador and San Pablo, which would apparently require a level of about 100 ft. Both these plans include two high dams and the eighteen miles of expensive sea level canal below Bohio.

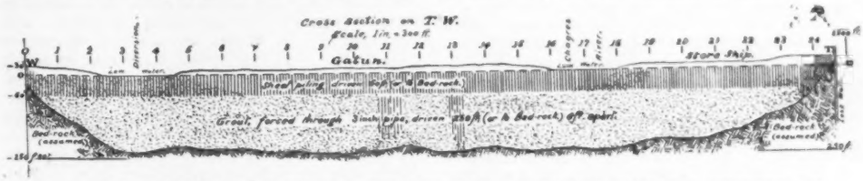

Cross Section on T. W.
Gatun.
Store Ship.
Grout, forced through 3 inch pipe, driven 250 ft. (or to Bed-rock) off apron.
Bed-rock (assumed)
Bed-rock (assumed)

FIG. 4. LONGITUDINAL SECTION OF PROPOSED DAM AT GATUN, SHOWING METHOD OF MAKING WATER-TIGHT WALL THROUGH CENTER OF DAM.

100-FT. LEVEL CANAL.

Obviously, from what has gone before, a 100-ft. level, with a dam at Gatun, is the most advantageous plan, unless the same dam could be located further down stream. This is forbidden by the topography, the range of hills crossing at Gatun being the farthest one north that has sufficient height. Such a dam would give a lake having an area of a least 100 square miles, subject to very slight fluctuations, and capable of settling for ages all the mud that the streams would bring into it, and with no current of moment in its narrowest parts during the highest floods.

In the dry season it would have for lockage, not only the flow of the Chagres proper, but its own immense storage, and the flow of the Trinidad, Gatuncillo, and other numerous tributaries located in the region of heaviest rainfall. The dam could be built of the spoil from the Culebra cut, and its cost per ton would be only the cost of hauling it about 25 extra miles. It has to be loaded on the cars and hauled several miles and be dumped in any event. Moreover, dump grounds of the necessary capacity are not plentiful near Culebra, and it is quite probable that the later excavation may have to be hauled quite long distances.

By such a dam all the expense of the nine miles of crooked canal between Bohio and Gatun would be saved, and replaced by the open navigation of a broad, deep lake. The Gatuncillo would be taken into this lake and all trouble from it removed.

The saving in cost would be so great that the funds now authorized could probably cover also a canal through the summit cut deep enough and wide enough for all future needs, as well as a deep and wide straight entrance to the locks from Limon Bay, both conducing to safety and celerity of passage.

To attain these important results, the following general plan, based on what the present state of knowledge of the locality indicates as probable conditions, is suggested:

The island (Fig. 3) on which the lock for present needs (L. K.) is shown is, at least at its upstream end, of rock or firm clay suitable for a lock foundation. The ridge running from S to W where the spillway is shown is undoubtedly rock. The diversion cut, started at O, was abandoned, and had to be moved over to S before a soft place could be found. The depth of rock at S is unknown, but it is doubtless only a short distance. This forms an admirable foundation for the concrete spillway.

The site of the dam, whose crest is shown at D. M., is apparently sand and gravel, possibly 200 ft. to bed rock. The dam shown is 200 ft. wide on the crest, 120 ft. high, and 2,000 ft. wide on the base. It contains about 18,500,000 cu. yds. of material which, at an estimated cost for hauling of ½ ct. per ton mile, or about 15 cts. a cu. yd., would amount to $2,800,000. This dam would be amply wide and heavy to be safe against rupture from any imaginable cause.

To stop seepage through the dam itself would be a simple matter. If the upstream portion is made of clay and other finer materials protected by rocky material, and the rest of the dam mostly of coarser material, seepage will be unimportant. Seepage under the dam through the "water-bearing" material which fills the alleged "geological valley," seems to have caused more alarm than need be. The fear is that it would let too much water escape in the dry season. Assuming that the minimum cross section under the dam has a width of 2,000 ft. and an average depth of 200 ft., which seems to be ample, we would have a cross sectional area of 400,000 sq. ft. Regarding this as a filter bed with a thickness of 2,000 ft., it scarcely needs demonstration to show that the yield of such a filter would be relatively unimportant to a lake of 100 square miles of area, which would be receiving the flow of the entire Chagres basin at the same time. With large quantities of fine mud brough down by the Gatuncillo, together with the foliage from the submerged jungle, the filter would soon clog completely.

However, to dissipate all doubts on the subject, the sealing of the valley is a comparatively easy matter. Interlocking steel sheet piling can be driven, say on the line W. T., to a depth of, say 60 ft., as shown in the sketch, Fig. 4.

This would greatly reduce the "filter" area. Then, immediately alongside this line of sheeting, 3-in. pipes could be driven in succession to bed rock 5 to 6 ft. apart, and thin Portland cement grout, made of specially finely ground cement, forced down each under a pressure equal to 100 ft. head of water, and the pipe gradually pulled up as to the flow of grout ceases.

If the pressure of the future lake, 100 ft. deep and a thousand or more feet away, will force any water through the material of the filter on this line, the pressure of the pump should force the grout into the surrounding material with a greater velocity and force. Hence, if the future seepage is to amount to anything, the pump pressure will force the grout into enough of the surrounding material to convert a sufficient thickness of it into tight artificial rock at a very trifling expense compared with a masonry core. If steel sheet piling rusts away, the iron and lime cement formed by the process will make a tight joint. The sheet piling is necessary because near the surface pump pressure might force the grout up alongside the pipe instead of into the sand and

Fig 5.

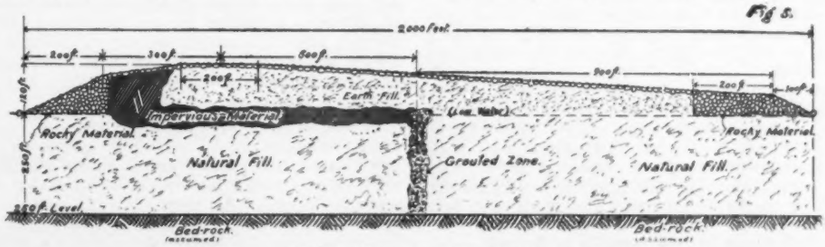


FIG. 5. CROSS-SECTION OF GATUN DAM.

gravel. If any layers of impervious material are encountered that will not take up any cement, it will be because they are tight enough already and do not need it. Of course there is no danger of such a cemented water tight wall being ruptured by pressure, because it would be backed by unlimited material settled in place for ages. Should any compressible material exist, the weight of the dam over it would promptly squeeze it down tight and solid. There is no probability of such compressible material below the proposed sheet piling.

Of course, the vegetation, surface mould, etc., should be dredged away from the water-tight section to the zone of impervious material in the upstream portion of the dam. A cross section of the suggested dam is shown below in Fig. 5. Both the dam and the grouted zone are, in general, essentially similar to structures mentioned in the above paper by Mr. Morison, and its discussion. This discussion clearly demonstrates to the writer's mind that the plan would be successful at Bohio. If so, there is no imaginable reason why it would not work at Gatun.

If the grouted zone and sheet piling are used the width of cross-section of the dam can be considerably reduced.

The surface of the dam should be largely of rock, with an area near the crest composed of rock too large to move by hand. Then, if a forest of trees, with interlacing roots, be planted all over the surface, the dam is proof against accident or design. Needless to say, possible damages by crawfish or muskrats are easily prevented in such a dam.

The masonry tees, R. T., V. X., and A. B., extending from the lock wall, will effectively stop any percolation along the lock wall, and at the same time provide for the crest of the dam being ten feet above the wall. They should be built up from solid material.

The locks are assumed as of 900 ft. useable length, and 90 ft. useable width. This will take the largest ships afloat, or projected, that are likely to use the canal, with a good margin for future growth. When they become too small, another flight of any size required can be built in the space left alongside. When that in turn is outclassed, the old one can be rebuilt still larger, and so on indefinitely.

The lifts, beginning at the lower end, are 35, 35 and 30 ft., making 100 ft. to the level of the spillway. The upper wall is 10 ft. higher than the spillway, making it 5 ft. higher than the highest possible flood. The dam will thus be 15 ft. above the highest water.

The spillway is a concrete dam, 100 ft. high, 20 ft. wide on top, and 60 ft. wide at bottom, with a concrete foundation up to sea level, and extending 100 ft. down stream, to take the wear of the spillway. Where it crosses the diversion cut near the lock wall, this foundation may be 20 ft. or more deep. The first 1,000 ft. of the foundation next the lock will be up to sea level. The rest may be in steps to fit the rock ridge.

CONSTRUCTION.

This 1,000 ft. of spillway foundation next the locks will be the first work done. Then the sheet piling and grouting of the water-tight area under the dam should be placed, a temporary dam, about 10 ft. above low water, being previously built along the upstream toe of the earth dam on the line, G. G., to turn the water over the 1,000-ft. spillway foundation. After that, all work can proceed with no danger from floods. The locks, the dam and the head-wall across the site of the future lock-site can be built without the slightest danger of interruption from high water, a most important element of economy in such work, and one which, by the way, does not pertain to the Bohio site. The temporary dam will form part of the main dam which, under its protection, can be built exactly as desired.

While these works are being built, work on the spillway can be carried on. This will consist of a series of arches, the lower portions of the pillars of which could be put in with the foundation. The arches will be sufficiently large to pass all flood waters without over-topping the temporary dam. When the works are all completed, the arches can be closed by temporary covers, and then permanently filled with concrete. If desired, enough of them could be closed with valves to permit of the future emptying of the pool, but it is hard to conceive of any occasion for this.

Should the lock foundation prove too short for a flight of three locks, there is nothing to forbid a flight of two, with lifts of 50 and 55 ft. The existing prejudice against locks of greater lift than 35 ft. is based on the difficulties inherent in gates with miter sills. But if single straight floating caisson gates be used, there is nothing to prevent almost any reasonable lift. If a successful lock of 25-ft. lift be increased in proportion in all its parts, there is certainly nothing in physics to prevent its successful operation. The enormous lateral thrust of mitering gates requires, with high lifts, great masses of masonry not otherwise needed, so it is cheaper and much simpler in such cases to use single gates whose thrust is longitudinal with the walls. With such gates the complications of a miter sill are avoided, as no sill of any kind need be used, the steel gate simply resting with its full weight on a smooth steel surface securely anchored to the concrete. The limits of this paper prevent the details of the plan of locks and gates being given.

ESTIMATES.

The earth part of the dam would cost, as indicated above, about	$2,800,000
The sheet piling, about	300,000
The grouting, about	500,000

This assumes that the driving of the pipe will cost $1 a foot, which is ample, and that pipes 6 ft. apart will be necessary. It is also assumed that one-fifth the material is voids, and that the grouted zone is 6 ft. thick.

The locks will contain about 400,000 cu. yds. of concrete, which, at $10 a yd., would amount to	$4,000,000
Add, for gates and valves	500,000
And for contingencies	400,000
We have a total cost of	$4,900,000
The spillway and its foundation will contain about 350,000 cu. yds., which, at $10 a yd., would be	$3,500,000

The above estimates are based on a navigable depth of 40 ft. of water.

A liberal estimate for the breakwater at Colon is $5,000,000.

A straight cut from Limon Bay to the lock, 40 ft. deep and 300 ft. wide on the bottom, with side slopes of 1 vertical to 2 horizontal, at $1 per cu. yd., some of it being possibly rock, would cost about $25,000,000.

With this breakwater and straight entrance, the inner harbor could be omitted.

The necessary cut at Culebra cannot be exactly estimated from the facts on hand:

For a sea-level canal, 35 ft. deep, the chief engineer estimates	$125,000,000
For a 30-ft. level	86,000,000
For a 60-ft. level	59,500,000
At the proportional rate of decrease, a 90-ft. level should be about	44,000,000

Assuming this for our 100-ft. level, which would give 45 ft. in the cut, we would have for the total cost of the canal, from Colon to Pedro Miguel, a total of about $86,000,000; leaving of the present authorized $140,000,000, about $54,000,000, to build three locks on the Pacific side, and dig the canal between them. The total distance is ten miles, and the total excavation not more than 20,000,000 yds. 60 cts. a yd. should be ample for this, making $12,000,000.

The locks being all on rock foundation, $2,500,000, each should suffice, making $7,500,000, which should leave a balance for contingencies of $34,500,000, after the completion of a canal 5 ft. deeper and much wider than those on which comparative estimates are based.

TIME OF CONSTRUCTION.

In this, as in all other suggested plans, the auxiliary works can all be readily completed before the Culebra cut. This plan, involving the least work on that cut, can therefore be completed the soonest. It should be noted that comparisons of time and cost of the various plans cannot be correctly based on the comparative amounts of excavation alone. As the cut is deepened, contingencies as to slides, congestion of plant, drainage, and increase in hardness and quantity of rock, must be allowed for. The removal of one yard of material below sea level for that type of canal, when the cost of pumping and the other above contingencies are counted, will doubtless amount to more than the cost of removing five or six yards for the 100-ft. level canal, and the proportionate delays would make the matter of time much worse for the sea level canal. It has been estimated that the latter can be completed in ten or twelve years. If so, the 100-ft. level should be finished in less than five years.

Under these circumstances it would appear proper to give the dam site at Gatun a much more thorough examination than has heretofore apparently been accorded it.

THE NEW BRITISH STANDARD RAIL SECTIONS.

British engineers have now followed the example of American engineers in endeavoring to reduce the unnecessary number and variation of rail sections to a uniform standard. The slight variations in sections of the same weight have little or no influence upon the wearing qualities of the rails, and are due mainly to the desire of individual engineers to embody their own ideas in the rails for their own particular roads. The American Society of Civil Engineers commenced its investigations into rail design and manufacture in 1873, and in 1890 appointed a committee to prepare designs for standard rail sections in an endeavor to reduce the number of existing sections to some standard of uniformity. In 1893 this committee made its report, which was adopted, and since then the sections recommended by the committee have come to be almost universally used. In England, the Engineering Standards Committee (representing the five leading engineering associations) appointed a committee on rails in 1901, and this was divided into a sub-committee on street railway rails and a sub-committee on railway rails. The report of the former was approved and issued in 1903, and the latter has since issued sections and specifications for bull-headed and T-rails. The bull-headed rails are not of much interest to engineers in this country, except that American mills sometimes roll such rails for foreign railways. There are nine standard sections varying by 5 lbs. from 60 to 100 lbs. per yd., and these have vertical sides to the heads, with radii of 12 ins. for both heads, and fishing angles of 20°. The top corner radius is ⅜-in. for rails of 60 to 80 lbs. per yd., and ½-in. for rails of 85 to 100 lbs. per yd. The distribution of metal varies with each weight of section, and has the following range:

	60-lb. rail, per ct.	100-lb. rail, per ct.
Head	46.4	50.12
Web	21.8	20.05
Base	31.8	29.83

There are 17 T-rail sections varying by 5 lbs. from 20 lbs. to 100 lbs. per yd. These sections are similar to those of the American standards in the following features: (1) The height and the width of base are equal; (2) the sides of the head are vertical, and (3) the top radius of head is 12 ins. They differ from the American sections in the following respects: (1) the distribution of metal is not uniform throughout the series; (2) the top corner radius is larger, and is not uniform; (3) the fishing angle is 14° instead of 13°; (4) the upper face of the base has not a uniform slope, but a much flatter slope beyond the bearing surface of the splice bar; (5) the sides of the web are vertical instead of curved; (6) the bottom corners of the base are sharp instead of rounded. The feature which most calls for criticism is the round top corner for the heavier rails; this radius being ¼-in. for sections of 20 to 40 lbs. per yd., 11-32 for sections of 45 to 60 lbs. per yd., and ⅜-in. for sections of 65 to 100 lbs. per yd. The distribution of the metal varies with each weight of section and has the following range:

	British.		American.
	20 lbs. per yd., per cent.	100 lbs. per yd., per cent.	40 to 100 lbs. per cent.
Head	47.05	45.19	42
Web	16.71	18.41	21
Base	36.24	36.40	37

The accompanying cut shows the comparative forms of the American and British 80-lb. sections, and their comparative dimensions are given in the accompanying table.

The principal parts of the specifications are given below, and it may be noted that those for the bull-headed rails call for similar chemical

	—80-lb. Rails.— American ins.	British ins.	—100-lb. Rails.— American ins.	British ins.
Height	5	5	5¼	5¼
Width of base	5	5	5¼	5¼
Width of head	2¼	2¼	2¾	2¾
Depth of head	1⅛	1⅛	1⅛	1⅛
Height of web	2⅝	2⅝	3⅛	3
Depth of base	⅞	⅞	⅞	⅞
Thickness of web	11/32	11/32	⅜	11/32
Radius, top of head	12	12	12	12
" top corner of head	1/16	3/32	1/16	3/32
" bottom corner of head	1/16	1/16	1/16	1/16
" top fillets	¼	¼	¼	¼
" bottom fillets	¼	¼	¼	¼
" corners of base	1/16	top 1/16	1/16	top 1/16
" sides of web	12	Vert.	12	Vert.
Edge of base	Vert.	Vert.	Vert.	Vert.
Fishing angles	13°	14°	13°	14°
Slope of base beyond fishing angle	....	1 to 10	....	1 to 10
Metal in head	42%	44.47%	42%	45.19%
" web	21%	18.71%	21%	18.41%
" base	37%	36.82%	37%	36.40%

composition except that the phosphorus is increased to 0.075% and the sulphur to 0.08%.

The steel for the rails shall be of the best quality made by the Bessemer, Siemens-Martin or other process, to be approved by the engineer (or by the purchaser).

The rails shall show on analysis that in chemical composition they conform to the following limits:

Carbon, 0.35 to 0.5%; manganese, 0.7 to 1%; silicon, max., 0.10%; phosphorus, max., 0.07%; sulphur, max., 0.07%.

The manufacturer shall make and furnish to the representative of the engineer (or the purchaser) carbon and phosphorus determinations of each cast.

A complete chemical analysis, representing the average of the other elements contained in the steel, shall be similarly given for each rolling. Such complete analysis shall be made from drillings taken from the rail or tensile test-piece or pieces. When the rolling exceeds 200 tons, an additional complete analysis shall be made for each 200 tons or part thereof.

Should the engineer desire to make independent chemical determinations, the necessary specimens and samples shall be furnished by the manufacturer. For this purpose not more than two rails in every hundred manufactured shall be selected by the engineer and drillings taken with a drill of 2 ins. diameter from the top of the head of the rail, unless otherwise specified by him, and if, upon being subjected to the specified tests, either fail to comply therewith, then all the rails in the blow of which the test pieces form a part may be rejected. In case of difference between the engineer (or between the purchaser) and the manufacturer, as to the accuracy of an analysis, either party shall have the right to have samples of the steel analyzed by an independent metallurgist, to be mutually agreed upon. The expenses attendant upon such independent analysis shall be borne by the party adjudged to be in the wrong.

Each rail shall be made from an ingot not less than 12 ins. square at the smaller end and 14 ins. square at the larger end, which must be cogged down into blooms, and have sufficient crop then sheared from each end to ensure soundness.

A rolling margin of ½% under to ½% above the specified weight will be permitted, but the contract weight only will be paid for.

The whole of the rails shall be of uniform section throughout, true to templates, perfectly sound and straight, and free from splits, cracks, burrs, and defects of every kind.

A quantity of short lengths will be taken in such lengths and quantities as may be ordered by the engineer (or by the purchaser) provided that these short lengths are cut down from longer lengths found to be defective at the ends only, and that the total quantity taken does not exceed 7½% of the contract.

The rails shall be the specified length at a temperature of 60° F. No rail will be accepted which is more than 5/16-in. above or below the length specified, whether for straight or curved lines.

When required by the engineer (or by the purchaser) rails are to be supplied from 1 to 6 ins. shorter than the normal specified lengths, and these special lengths are to have about one foot at each end painted with such colors as may be ordered.

The brand shall be rolled on the web of each rail to show that the rail is of British Standard Section and made under the conditions of this specification; the number of the "B. S." section (being the nominal weight of the rail in lbs. per yd.), the process by which the rails have been manufactured, the manufacturer's name, initials, or other recognized mark, and the month and year of manufacture shall also be rolled, in letters ¾-in. in size, on one side of the web of each rail, and the number of the cast or blow from which it has been rolled shall be stamped on the ends of each rail in ½-in. block figures.

From each cast a piece of rail shall be selected by the inspector and stamped with his mark and the number of the cast. From this a piece 5 ft. long shall be cut which shall be placed in a horizontal position, with the head uppermost, on two iron or steel supports resting on solid foundations, the upper surface of the supports being curved to a radius of 3 ins.; this sample may be taken from a crop end. The test shall comprise one blow, delivered midway between the bearings, from a falling weight, the striking face of which shall be curved to a radius of not more than 5 ins. In addition to the above test, the inspector shall select one finished rail from every 200 offered and a piece 5 ft. in length cut from this rail shall be similarly tested as specified above.

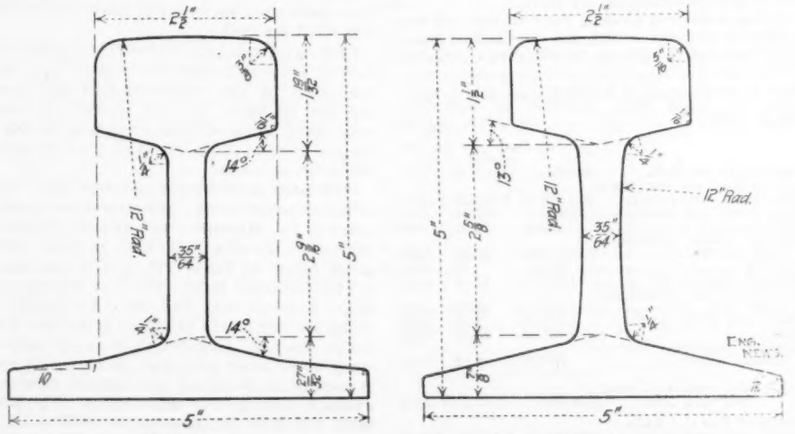
(The weight of hammer is 2,240 lbs. for rails of 60 to 100 lbs. per yd. The distance between centers of bearings is 3 ft. for rails up to 65 lbs., and 3 ft. 6 ins. for rails of 70 lbs. and over per yd. The fall is 20 ft. for 60 to 75-lb. rails, 22 ft. for 80-lb., 24 ft. for 85-lb., 26 ft. for 90-lb., 28 ft. for 95-lb. and 30 ft. for 100-lb. rails.—Editor Engineering News.)

Should any rail show fracture under the falling weight test, the entire cast from which it was selected shall be rejected.

From each 100 tons of rails the manufacturer shall (if required by the representative of the engineer or of the purchaser) cut a test piece from any rail selected as a sample rail; such test piece to be stamped to correspond with the sample rail. It shall then be placed in a testing machine of approved pattern, and shall show an ultimate tensile strength equivalent to not less than 40 tons per sq. in. nor more than 48 tons per sq. in., with an elongation of not less than 15% upon the standard test pieces 0.564 in. or 0.798-in. diameter, equivalent to ¼ or ½ sq. in. sectional area). Should the test piece fail to fulfil these conditions, the representative of the engineer (or of the purchaser) may require the manufacturer to test two other rails from the same cast in the same manner, and the acceptance or rejection of the cast shall be decided by the result of the three tests, so that if two of the three rails selected shall fail to comply with the test the entire cast will be rejected.

Should the engineer (or the purchaser) desire to have independent tests made, the manufacturer shall provide the necessary test pieces (two for every 200 tons), properly shaped and prepared as described on page ——.

The holes for fishbolts must be drilled through the web from the solid at each end of the rails, of the sizes and in the position shown on the drawing to be supplied by the engineer (or the purchaser). These holes must be clean and square with the web, without burrs on either side, and will be checked with the gages to be furnished to the manufacturer by the engineer (or by the purchaser). Should any of the holes vary from the correct size or position more than 1/32 in. the rails in question will be liable to rejection.



BRITISH AND AMERICAN STANDARD RAIL SECTIONS; 80-LB. RAILS.

SOME RECORDS OF MAINTENANCE-OF-WAY EXPENSES ON AMERICAN RAILWAYS.

In all accounting for engineering construction and maintenance work, it is important that unit costs shall be determined or made obtainable, but a class of work in which this feature is to a great degree neglected is that of railway maintenance-of-way. This has been shown very strongly as the result of a recent investigation of this subject, and we present herewith some of the information obtained, while in another column we have discussed the general subject. The annual reports of railway companies form the most available source of information, but these give merely totals and lump sums, from which no definite comparisons or deductions can be made. Beyond these, there is little information to be had, and division reports as a rule do not enter into greater detail. As a rule, the reports give the total expenditures under a certain limited number of headings, and in rare cases their relation to the operating expenses are shown. The Hocking Valley Ry. is an example of this, and Table I. shows the percentages for the years 1903 and 1904 (omitting the actual sums). It should be explained that the percentage on this road (10%) is lower than on most roads:

TABLE I. Ratio of Maintenance Expenses to Operating Expenses—Hocking Valley Ry.

	Percentage of Operating Expenses 1903.	1904.
Repairs of roadway	4.46	4.84
Renewals of rails	0.95	1.15
Renewals of ties	1.49	1.69
Repairs and renewals of bridges and culverts	1.36	1.09
Repairs and renewals of fences, road crossings, signs and cattle guards	0.25	0.20
Repairs and renewals of buildings and fixtures	1.37	1.23
Repairs and renewals of docks and wharves	0.07	0.03
Repairs and renewals of telegraph	0.04	0.05
Stationery and printing	0.01	0.01
Other expenses	0.02	0.02
Total percentage of operating expenses	10.02	10.31

The Illinois Central Ry. and the Atchison, Topeka & Santa Fe Ry. give in their reports tables of the average annual cost of maintenance-of-way and structures per mile of line, but while this is interesting in default of anything better it must be remembered that the amount of work varies considerably each year, while the length of road remains practicably constant, so that a low cost per mile may be due to a small amount of work rather than to an actual low cost of the work. The figures for these two roads are given in Table II.

TABLE II.—Annual Expenditures for Maintenance-of-Way and Structures per Mile of Road.

	Illinois Central Ry.	A. T. & S. F. Ry.
1897	1,148	975
1898	1,127	1,194
1899	1,167	1,060
1900	1,448	866
1901	1,390	824
1902	1,321	782
1903	1,376	1,168
1904	1,308	1,121

Following this a little further we have taken the items of rail renewals and tie renewals, which are two important items of maintenance-of-way expenses, and calculated the average cost per mile of road and per mile of track (including sidings) for a number of railways. These again are of some general interest, but their value is materially decreased from the fact that the number of miles on which work was actually done cannot be ascertained. However, the figures are given in Table III., and it will be noted that on 16 of these 20 railways the cost of tie renewals was more than that for rail renewals, the opposite being the case only on the Buffalo, Rochester & Pittsburg Ry., the Norfolk & Western Ry., the Wabash Ry. and the Cincinnati Southern Ry.

TABLE III.—Annual Expenditures for Rail and Tie Renewals in Dollars.

	Rail renewals, —per mile.— Of line.	Of track.	Tie renewals, —per mile.— Of line.	Of track.
N. Y., N. H. & H.	47	23	290	144
Erie	90	70	162	122
Lehigh Valley	124	60	433	225
Del., Lack. & West.	183	73	349	138
N. Y. Central	148	70	322	150
N. Y., O. & West.	80	62	246	190
Buffalo, R. & P.	241	143	136	80
Phila. & Read	106	68	389	160
Balt. & Ohio	104	60	126	73
Norfolk & Western	202	143	196	140
Ches. & Ohio	127	87	141	97
C. C. C. & St. Louis	45	29	133	80
Wabash	140	100	130	100
Cincinnati So.	206	135	104	68
Hocking Valley	171	96	260	146
Chicago & E. Ill.	30	19	129	74
Chi., Ind. & L.	106	80	205	155
Chicago & N. W.	34	24	95	66
Chi., Mil. & St. P.	97	71	126	92
A. T. & S. F.	127	100	147	118
Maximum	241	143	433	225
Minimum	30	19	95	66

PENNSYLVANIA LINES.—One of the maintenance-of-way officers kindly undertook to procure information as to itemized expenses, but finally stated that he had not been successful in getting from the division officers, when he asked for the information, any satisfactory replies. The reasons for this are as follows: 1. The prime object for division in the accounts is to furnish the auditor with the knowledge he desires, and the subdivision

is made accordingly. 2. Further subdivisions are made for the use of operating officers, and do not go any more into detail than they consider necessary for the object they desire to attain. The maintenance-of-way accounts, therefore, are kept under the following general heads and sub-heads:

1. Engineering and superintendence: A, Pay of officers; B, Pay of clerks and attendants; C, Office and traveling expenses.
2. Track maintenance.
3. Applying track material: A, Rails; B, Ties; C, Ballast.
4. Roadway clearing and policing: A, Care of roadbed; B, General cleaning; C, Snow and ice; D, Patroling and watching; E, Refuse material.
5. Ballast.
6. Rails.
7. Ties.
8. Track appliances: A, Rail fastenings; B, Frogs and switches.
9. Roadway tools.
10. Other roadway maintenance: A, Tunnels; B, Viaducts; C, New tracks; D, Bank protection; E, Filling; F, Other expenses.
11. Bridges and culverts: A, Structures; B, Watchmen and supplies; C, Other expenses.
12. Buildings and grounds: A, Buildings; B, Furniture and fixtures; C, Incidental building expenses; D, Machinery and fixtures; E, Other expenses; F, Driveways and grounds.
13. Docks and wharves: A, Repairs; B, Dredging and cleaning.
14. Interlocking plants and signals: A, Interlocking plants; B, Automatic signals; C, Other expenses.
15. Fences, road crossings and signs: A, Highway grade crossings; B, Other crossings; C, Fences; D, Other signs.
16. Telegraph and telephone lines.
17. Electric traction lines.
18. Stationery and printing.
19. Insurance.
20. Incidentals.

The auditor cares only for the general heads, while the division officers keep their accounts under the sub-heads. It will be noted that records are not kept in such a way as to give unit cost, but when a division officer desires some information on unit cost it is necessary for him to work it up. Occasionally it is necessary to go back to the time books for information. It will also be noted that frogs and switches are kept together; therefore, when it is desired to compare one frog with another, or one switch with another, an actual record is begun for the particular case in hand, and followed up until results are arrived at. It is evident therefore, from what has been said that it is impossible to obtain, off-hand, from the accounts the unit cost of the various appliances because the accounts are not kept in that way.

Later, however, we were kindly furnished with a report from one of the divisions relative to cost of maintenance-of-way work for the year 1903. The information, as given in Table IV, is as full as could be obtained, and is based on track mileage.

LOUISVILLE & NASHVILLE RY.—This railway classifies its maintenance work more systematically than most roads, and not only gives average cost for certain items, but also shows the average tonnage carried per mile of track, so that some idea can be gathered as to the relation of traffic conditions to maintenance expenses. The figures in Table V, which have been furnished to us, are compiled from the company's annual report for the year ending June 30, 1903, and relate to the main system, from Louisville to Nashville, 185.92 miles. The following note also explains what work and expenses are covered by the principal items:

1. Main Track.—Labor of cutting and replacing old rails with old rails; all fastenings used (except those used on renewals of rails) less value of old fastenings removed; labor of surfacing, lining and tamping track; sloping and cleaning out ditches; work on track in tunnels.

2. Side Tracks and Switches.—Labor and material for repairing side tracks (ties, rails, spikes, splices, bolts, washers and nut locks), less value of old material removed; replacing and repairing frogs and switch rigging, salt, oil, etc.; switch signals, repairs and renewals, oil, wicks and attending same.

3. Embankments.—Widening and filling.

4. Cutting Weeds and Cleaning Right of Way and Station Grounds.—Includes cutting sod line, making handcar rests, and making pathways for brakemen at switches.

5. Tunnels.—Work exclusive of track repairs (see No. 1).

6. Ballast.—Labor and material of renewing stone, gravel, slag or cinder ballast; also expenses of work trains in distributing material along the track for such renewal.

7. Fences, Road Crossings, Signs and Cattleguards.—Labor and material for renewal or repairs of fences, overhead bridges, roads under tracks, street and road crossings, street repairs or sewers for which assessments may be made, safety gates and signals at same, whistle boards, crossing signs and mile posts, cattleguards and approaches.

9. Tools.—Jacks, picks, lamps, chisels, toolboxes, etc., used for repairs of roadway and track.

10. General Expenses.—Repairs of boarding cars and fixtures for same; and all other expenses of maintenance of roadway and track not otherwise provided for.

12 and 13. Replacing Ties.—Labor of replacing old ties with new ones, showing number of ties.

14 and 15. Distributing Ties and Rails.—Expenses of work trains, etc., handling and distributing the ties and rails along the track.

CLEVELAND, CINCINNATI, CHICAGO & ST. LOUIS RY.—In Table VI we have been given a statement of the maintenance-of-way expenses for the Michigan Division during the calendar year 1903, being divided according to the company's system of distribution. This division has 249 miles of track.

CHICAGO & NORTHWESTERN RY.—The cost of maintenance of way and structures on the 1,300 miles of the Minnesota and Dakota Divisions for the twelve months July, 1903, to June, 1904, are given below in Table VII, which has also been kindly furnished to us. The cost is separated for labor and material, but the classification is so broad and the length of line so great that with the entire absence of figures showing the amount of work done, labor employed or materials used, it is impossible to obtain any definite figures. The average expense per mile, however, is $285 for labor and $180 for material, or $465 in all. This cannot be compared with the $1,093 per mile for the 249 miles of the Michigan Division of the Cleveland, Cincinnati, Chicago & St. Louis Ry. as given above, because the items included and the distribution are not the same in both cases.

We have already stated that on very few railways is information obtainable even by the engineers in the maintenance department, as to itemized expenses or unit cost, and that this is the case is very emphatically shown by the following statements made by engineers on a number of railways in reply to requests for information as to details of maintenance expenditures and the methods of accounting employed in the maintenance departments. It also appears that some engineers are devising special systems of this kind for their own information, and in another column we have discussed the desirability of a more complete and systematic method of classifying the expenditures and keeping the accounts:

TABLE IV.—Pennsylvania Lines (Division Report on Maintenance-of-Way Expenses).

First main track			188.5 miles
Second main track			36.2 miles
Company sidings			96.5 miles
		Labor.	Material.
Cleaning snow and ice		$ 2,872.15	.....
Shimming track		816.50	.....
Patrolling		4,155.00	.....
Ditching		1,241.55	.....
Banking		1,525.00	.....
Renewing rails		3,303.75	.....
Work train charge	$540.55	.....	.....
Fuel charge	179.45	.....	.....
New rails, 2,133.6 tons.	16,003.95	.....	.....
Repair rail, 288.66 tons..	1,719.10	.....	$18,443.05
Renewing ties		10,173.30	.....
52,988 No. 1 cross ties..	33,750.88	.....	.....
24,666 No. 2 cross ties..	12,739.03	.....	.....
66,202 ft. switch ties...	1,270.12	.....	.....
Work train charge.....	1,062.30	.....	.....
Fuel charge	369.75	.....	49,192.08
Ballast, loading, unloading, etc., 2,882 flat cars, 1 ballast, 19 mi., 4,435 ft. track		1,331.80	.....
Ballast:			
Work train charge.....	1,435.25	.....	.....
Fuel charge	436.74	.....	1,871.99
Putting in frogs and switches.....		860.40	.....
53 frogs	2,194.10	.....	.....
26 switches	1,089.51	.....	3,283.61
Respacing		1,747.20	.....
Lining and surfacing track.....		28,475.10	.....
Gaging		3,280.10	.....
Cleaning right of way		2,922.65	.....
Work train charge.....	196.15	.....	.....
Fuel charge	49.07	.....	.....
Mowing weeds		4,232.95	.....
Renewing track fastenings, tightening bolts and spikes		3,115.35	.....
Work train charge	13.90	.....	.....
Fuel charge	4.85	.....	.....
5,803 pairs angle bars..	6,570.47	.....	.....
516 kegs bolts	2,821.33	.....	.....
845 kegs spikes	3,829.69	.....	.....
57,208 nut locks	418.96	.....	.....
508 rail braces	76.87	.....	.....
19,131 tie plates	2,495.06	.....	16,231.13
Miscellaneous M. of Way		1,955.25	.....
Miscellaneous not M. of Way		1,674.65	.....
Engineer and superintendents		6,612.00	.....
Total		$80,304.20	$89,267.08
Grand total			$169,571
Average per mile of road			900
Average per mile track, including company sidings			528

TABLE V.—Maintenance of Roadway, Louisville & Nashville Ry.; (Main Stem, Louisville to Nashville); 185.92 miles.

Classification of Work.	Amount.	Cost per mile of road.	Cost per rev. train mile, cts.
Repairs of Roadway and Track.			
1. Main track and roadway	$59,542.54	$ 320.26	$ .2540
2. Side tracks and switches	36,733.44	197.58	.1567
3. Embankments	3,645.99	19.61	.0156
4. Cutting weeds, cleaning right of way, etc.	10,611.45	57.08	.0453
5. Tunnels	172.13	.93	.0007
6. Ballast—Repairs of	2,876.64	15.47	.0123
7. Fences, road crossings, signs, etc.	6,728.11	36.19	.0287
8. Hand and dump cars	1,214.96	6.53	.0052
9. Tools	4,427.89	23.82	.0188
10. General expenses (miscellaneous items)	936.40	5.03	.0040
Total repairs of roadway and track	$126,889.55	$682.50	$ .5413
Renewals of Ties and Rails.			
11. Cross ties used—value	$23,915.31	$ 128.63	$ 1020
12. Labor replacing main track ties	5,804.93	31.22	.0248
13. Labor replacing side track ties	1,554.94	8.37	.0066
14. Handling and distributing ties	332.77	1.79	.0014
Total cost renewal of ties	$31,607.95	$170.01	$ .1348
15. New steel rails used, value, less old	$39,106.83	$ 210.34	$1.6683
16. Distributing and laying new rails	4,278.68	23.01	.1825
17. Material, joint fastenings, spikes, chairs, etc.	17,738.45	95.41	.7567
Total cost renewal of rails	$61,123.96	$328.76	$2.6075
Total	$219,621.46	$1,181.27	$3.2836
Cross ties used, main track, number			66,619
Cross ties used, side tracks, number			20,284
Cost per cross tie		cents.	27.52
Cost of labor replacing main track ties, per tie		cents.	8.71
Cost of labor replacing old ties with new in side tracks, per tie		cents.	7.67
Cost of handling and distributing ties, per tie		cents.	.38
New rails used (steel) tons			4,353.52
Cost per ton of rails (steel) less value of old rails			$8.98
Cost per ton for distributing and laying new rails			0.98
Length of road, main line, miles			185.92
Length of sidings, including second track, miles			145.96
Total number of miles of track			331.88
Mileage of passenger trains			721,853
Mileage of freight trains			1,608,577
Mileage of mixed trains			13,684
Total revenue mileage			2,344,114
Mileage of helping and empty engines			91,419
Mileage of switching, work, and pay-train engines			864,949
Total mileage of trains			3,300,482
Gross tonnage passed over one mile, viz.: Tonnage of revenue work and pay trains, including weight of engines and cars and also switch engines			7,883,597

TABLE VI.—Maintenance-of-Way Expenses; Michigan Division; C. C. C. & St. L. Ry.

	Total for 249 miles track.	Average expense per mile.
Superintendence	$9,813.80	$39.4128
Rail renewals	76.37	.3067
Tie renewals	34,287.62	137.7013
Track and roadway, labor	93,341.06	374.8637
Track and roadway, material	36,369.81	146.0635
Ballast	8,183.48	32.8654
Frogs and switches	3,317.93	13.3250
Ry. crossings and interlockings	2,296.55	9.2231
Fences, rd. cross. and cattleguards	8,012.95	32.1805
Bridges and trestles	27,886.52	111.9940
Track and bridge watchmen	101.45	.4074
Telegraph repairs	1,595.67	6.4085
Bldgs., sta. grounds and platforms	28,604.97	114.8794
Docks and warves	2.25	.0090
Land improvements	5,127.57	20.5928
Stationery and printing	218.27	.8766
Yards and sidings	12,935.87	51.9517
Total	$272,172.14	$1,093.0638

TABLE VII.—Maintenance-of-Way Expenses; Chicago & Northwestern Ry. (Minnesota and Dakota Divisions.)

	Labor.	Material.	Total.	Per mile.
Rails	.....	$34,436	34,436	26.50
Ties	.....	61,251	61,251	47.00
Superintendence	10,804	291	11,185	8.60
Repairs:				
Roadway and track	291,334	83,563	374,897	288.00
Interlocking plants	64	84	148	0.11
Block signals	220	323	543	0.42
Bridges and culverts	28,272	30,817	59,089	45.45
Buildings	34,896	16,361	51,257	40.00
Fences, road cross., signs and cattleguards	5,233	6,437	11,670	9.00
Total	370,913	233,563	604,476	465.00

1. PENNSYLVANIA R. R.—"We are laboring under the same difficulty that you are. Unfortunately the expenses for maintenance-of-way are divided to suit the recommendations of the Interstate Commerce Commissioners, and our road, as well as others, has established the different headings for expenses of maintenance of way, so that the subdivisions are not in accordance with the statements you mention, or do not give us the information we would like to receive. Particularly I would like to see the labor kept separate from other items, but the book of accounts does not do this. The most we get is the average cost per mile of road, as you state, under the large headings, and it is too indefinite to give us the items we would like to have. I might say that some years ago I made up a statement and I give some of the items from it, as follows: Of the entire expenses of maintenance-of-way, rails cost on different roads from 3.3% of the total to 11.7%; we might say that normally it would be from 7 to 8%, while cross-ties would average about 14%. I have nothing for fences or signs at crossings. Repairs of bridges and culverts represent between 7 and 8%."

2. PENNSYLVANIA LINES.—"In regard to the figures of the actual cost of track work, at different times I have tried to get this same information on our own lines, and have found it almost impossible to get correct figures."

3. MICHIGAN CENTRAL RY.—"It would afford me very great pleasure to furnish you the desired information, if same could be readily obtained. I know just what you want, and have frequently desired to make use of such information, but did not compile it as I found it would involve a large amount of work. Our maintenance-of-way accounts are kept in a manner prescribed by the auditor, not in detail. We have this year inaugurated, for our own information and guidance, a statement of accounts with each section on the road. I am thoroughly satisfied this will give us some very useful information and place us in position to check maintenance expenses of various divisions far more closely than we have been able to do in the past. Our division engineers keep in very close touch with the details of maintenance on their respective divisions, but at the same time do not prepare statements which would be in any way useful to you. I think it will be very difficult for you to obtain the itemized cost of work of different kinds on any particular division which will be of very great benefit, as you well know conditions vary a great deal on different parts of the road. For example: If we could now furnish you an itemized statement of the cost of different classes of work on any particular division of this road, such statement would be of little value, for the reason that next year a large amount of extra work might be done which could be charged to no other account than maintenance. In my judgment this information would be useful covering a period of several years and on the basis of an average only."

4. SOUTHERN PACIFIC RY.—"Referring to the actual cost of track work, particularly for itemized account and cost of work of different kinds on some individual division: Our accounts are not kept in such way that this can be readily determined. Our annual report gives the cost under general headings, and we of course have the accounts under the different headings prescribed by the railway commission, but as to the amount of work of different kinds on the different divisions, I have to rely on my personal knowledge of what is going on, which I of course obtain from personal inspection and from the daily and weekly reports. As to the amount of work, this of course depends on the condition of the property, on the present traffic, on changes which have taken place in the traffic, all of which, while known to the officers directly in charge, it is impossible to give in intelligible shape to anyone not familiar with the property."

5. ILLINOIS CENTRAL RY.—"In regard to figures showing actual cost of track work, I beg to advise that so far as I know the accounts are not kept in the manner you indicate. It would, of course, be possible to pick out the labor by itself, but we have neither time nor men to go into anything of this kind just now."

6. NASHVILLE, CHATTANOOGA & ST. LOUIS RY.—"In regard to information as to cost of maintenance of way, I regret to advise that we are not in a position to furnish such information. Our accounts are kept only under the Interstate Commerce Commission headings, and we have no accurate data as to cost of work done. But, after all, the question of the amount of work done being a relative one, the fixing of the cost is quite uncertain."

7. NEW YORK, ONTARIO & WESTERN RY.—"Referring to the actual cost of track work, I have to advise you that this cannot be separated any better than shown in the tables* in our annual report, and this of course should be divided by the number of miles operated. Any further separation of these figures I am unable to give you, as they have only been kept on a mileage basis."

*This is simply the broad classification of total expenditures, as required by the Interstate Commerce Commission.

8. PITTSBURG & LAKE ERIE RY.—"It is difficult to give you the information, as we charge so much that is extraneous to the accounts referred to."

9. CHICAGO & ALTON RY.—"I regret to say that I cannot give you the information you request, but I hope that another year we will be able to keep our maintenance-of-way accounts in such shape that we will be able to ascertain the cost of the more important details of maintenance."

10. LAKE SHORE & MICHIGAN SOUTHERN RY.—"We have no figures at hand that would give the information you want. The amount and cost of maintenance for any individual year would be of very little value and the standard of maintenance may vary also. This of course is true in the maintenance of main line and branches. Such information to be of any practical value would have to be an average determined by using the figures for a number of years. Another feature that would make such figures of little value as covering universal practice would be the fact that the standard and conditions of this line would be so different from those of many others."

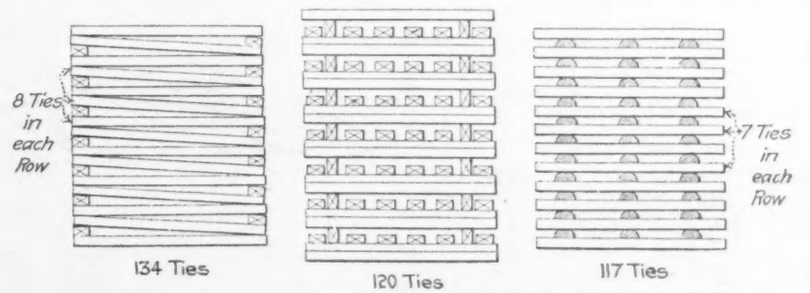
11. SOUTHERN RY.—"It is to be regretted that the actual cost of each division of track work has to be kept by section masters, who are selected for their skill as track men, rather than their ability as accountants, and for that reason, the railway accounts cannot well be divided with absolute accuracy. A section master, when putting in ties, retamps his track, at the same time lining and surfacing it, perhaps doing a little ditching or repairs to embankment at that particular time, and maybe devoting only a part of a day to each class of work. By the time he reaches home at night, the labor of accurately dividing the expense is more than he cares to perform, and as a result exact figures are hard to obtain. This has been my experience during the last 25 years and in view of the fact that the character of the roadbed, ballast, etc., is so different at various points and is also influenced by the amount of traffic, it seems to me only a general division can be made."

12. NEW YORK CENTRAL & HUDSON RIVER RY.—"I regret to say that the annual report of this company contains the only figures which are issued for publication. We publish no division results."

CREOSOTING WORKS OF THE WESTERN RAILWAY OF FRANCE.

Since 1899, the Western Railway of France has had in operation at Surdon a large plant for the preservative treatment of ties and other timbers by the creosoting process, and this plant is described by Mr. J. M. Merklen, Engineer of Stationary Plants, in the May number of the "Revue Generale des Chemins de Fer," from which we take the following particulars.

Ties of beech and oak are treated regularly, and several hundred elm ties are also treated every year. On delivery at the yards, they are piled in groups of the same kind and the same period of cutting, in order that the ties of each pile may, after seasoning, have about the same resistance to the penetration of the creosote. Oak ties are separated into rectangular ties containing little sap wood and half-round ties. Beech ties from Normandy and from Brittany are kept separate, and for each class the rectangular and half-round ties are also piled separately. Hewed and sawed rectangular ties are distinctively marked, as it is found that the sawing has a heating effect on the surface of the wood, which makes the injection more difficult. Three methods of piling are shown in the accompanying cut; the objections to the first (at the left) are that the work of stacking the ties is difficult and that the ties are liable to distortion from their own weight; the second plan is on the whole more satisfactory; the third is for half-round ties. During this open-air seasoning, which lasts from 6 to 12 months, the ties are frequently inspected, and those which crack are reinforced by ½-in. bolts or by S-shaped clamps of hoop steel driven into the ends. While the ties are treated only after a long period of seasoning in the open air, the seasoning is completed (especially in bad weather and for beech ties) by passing the ties through hot-air drying chambers. There are two of these, each with four tracks holding four tie-trucks, or 32 trucks in all. The ties remain here for about 24 hours, and the trucks are pushed forward in the opposite direction to the air current. In order to ensure uniformity, a truck from each track is pushed out at one time, while trucks with fresh ties are pushed in at the other end. For track with bull-head rails in chairs, the rectangular ties are used without cutting, but the half-round ties require to have seats formed for the chairs. For tracks with T rails secured by screw spikes, the ties have the seats cut and holes bored by machine. All this work is done before the preservative treatment.



METHODS OF PILING TIES FOR SEASONING; WESTERN RY. OF FRANCE.

The trucks going from the drying chambers in groups of four, as above mentioned, and containing ties of the same kind and the same period of cutting, are sent to the treating cylinders. The ties are placed parallel with the axis of the cylinders, and the rows are separated by angle iron brackets across the ends of the trucks, so as to allow free circulation of the hot air and the creosote. Each truck holds 35 to 40 ties. Under the train is a wire cable having one end attached to the rear axle of the rear truck, while the other end is attached to a similar cable on the train ready to go out of the cylinder. A third cable, attached to an electric drum, is coupled to the front of the train in the cylinder, and as this train is drawn out it hauls in the train of untreated ties. Movable sections connect the track in the cylinder with the outside tracks, so as to allow of the handling of the doors of the cylinder.

Each treating cylinder has two coils of steam heating tubes, each coil in one piece to avoid joints and so prevent any escape of water into the creosote. The coils have an exterior heating surface of about 80 sq. ft. Guard rails inside the cylinder ensure that the trucks will drop upon the rails after having been floated by the creosote. A vacuum is first created, then creosote is admitted from a tank and kept under pressure from 35 to 45 minutes. A complete operation takes about 1½ hours, including the emptying of the excess creosote from the cylinder. From 9 to 10 cylinder loads are treated daily, or 1,400 to 1,600 ties. The volume of creosote injected is shown by means of a float in the creosote tank, operating a gage or dial. The difference of level is taken in the readings before filling the cylinder, and after returning the excess amount from the cylinder; the capacity of the tank being known, the volume (and weight) of creosote absorbed can be determined. These observations are checked from time to time by weighing ten ties. Besides this, the penetration of the creosote into beech and elm ties is verified by boring. Ties with an insufficient impregnation are treated a second time, and even a third time if necessary.

The creosote is stored in three steel tanks in

the basement, heated by coils similar to those in the cylinders. The tank cars are emptied in one or other of the first two tanks, in which also any necessary addition of crude naphthalene is made.

In order to determine the efficiency of different preservative treatments, a "rotting bed" or forcing bed has been established. This is a trench 14.7 × 10 ft. and 20 ins. deep, filled with horse manure to a depth of 12 ins. The wood or ties to be experimented with are buried in the manure, which is then covered with 10 ins. of earth, in which are grown plants watered frequently to maintain a constant state of humidity. This has been found very useful, and has conclusively shown the superiority of the creosoting methods as employed at this plant. Pieces of beech wood not treated or improperly treated and placed in this bed in December, 1901, had decayed at the end of some months, while pieces properly prepared still remain in good condition. The value of the damp test in this bed is shown by the fact that pieces of untreated beech placed in a dry loft at the same time that the other pieces were put in the bed are still in excellent condition. As the result of careful investigation and long experience, the average amount of creosote to be injected is taken as 35 lbs. per tie (for beech), but owing to varying qualities and conditions of the timber the amount actually absorbed ranges from 26½ or 33 lbs. to 77 lbs. per tie. In 1903 the amount of creosote absorbed averaged 53.7 lbs. for each beech tie and 10 lbs. for each oak tie. This road has creosoted ties in use which have been in the track for 30 years, and chemical analysis shows that a large proportion of the naphthalene still remains while the phenols have almost entirely disappeared.

This plant has treated a large amount of the wood used by the maintenance-of-way department, and the output for 1903 was as follows:

Beech ties (1st treatment)	200,000
Beech ties (2d treatment)	17,500
Beech ties (3d treatment)	5,000
Oak ties	47,000
Oak ties for narrow gage	20,000
Switch ties	8,000
Total ties	297,500
Stakes for trellis work (fencing)	140,000
Stakes for signal wires	10,800
Tie-plates of poplar	30,000
Panels for floors of turntables	1,400
Oak fence posts	20,000

A UNIVERSAL DICTIONARY OF MECHANICAL DRAWING.*

By George H. Follows.†

Part IV.—Projection and Projected Views.

46. In the English language it is not at all uncommon for a word to have more than one meaning. Sometimes the several meanings of the same word are due to accident and cannot be clearly traced to any positive source, but generally by stepping back through the forms a word has had in different languages it is possible to get at its earliest form and to discover its original meaning.

47. Many of the words we use have their "roots" among what are known as the dead languages, Latin and Greek; while the origin of others is even more remote. Ruskin, in one of his lectures, speaks of "words of true descent, of ancient blood," and would have us know the history of all such words. This is perhaps expecting too much, but there is wisdom in the idea, especially if we are reading to acquire definite knowledge. If under such circumstances we come across a word that has a vital bearing upon the subject, and we are not quite sure of its true meaning, it is wise to go to the dictionary and look up its derivation. We have examples here in the words "project" and "projection," because they have several applied meanings and because it is of vital importance to understand their true significance in connection with mechanical drawing.

48. The Century Dictionary tells us that the verb "project" is derived from the Latin "projectare," out of the root words "jacere," to throw, and "pro," forth; and that its literal meaning is "to throw out or forth, to cast or shoot forward." The significance of the word as applied in mechanical drawing is "to throw forward in parallel rays or straight lines." And "projection" means "either the act or the result of projecting parallel rays from the surface of a body and of cutting these rays with a plane, so as to obtain on the plane a shape corresponding point for point with that of the body." (A "plane" is a perfectly flat surface; it has no thickness, and is therefore transparent.) In mechanical drawing the rays are called "projection lines."

49. It will thus be seen that the word "project" is not only of good and ancient lineage, but that as used in mechanical drawing its true significance is quite in keeping with its literal meaning.

50. In Fig. 6 a "body" is represented as projecting from its surface parallel rays, or "projection lines"; a "plane" is placed so as to cut these lines; and the intersections of the lines and the plane result in a "projection" corresponding in a shape with that of the body.

51. In mechanical drawing a projection of this kind is called a "view," meaning that it is the "view" that would be obtained by an observer stationed on the same side of the body as the projection plane. This use of the word view is of course conventional.

52. In Fig. 7 the same body is represented as projecting rays in three directions; three planes are interposed, a top plane, a front plane, and a

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†Of the Engineering Department, Westinghouse Electric & Manufacturing Co., The Park View, East Liberty, Pa.

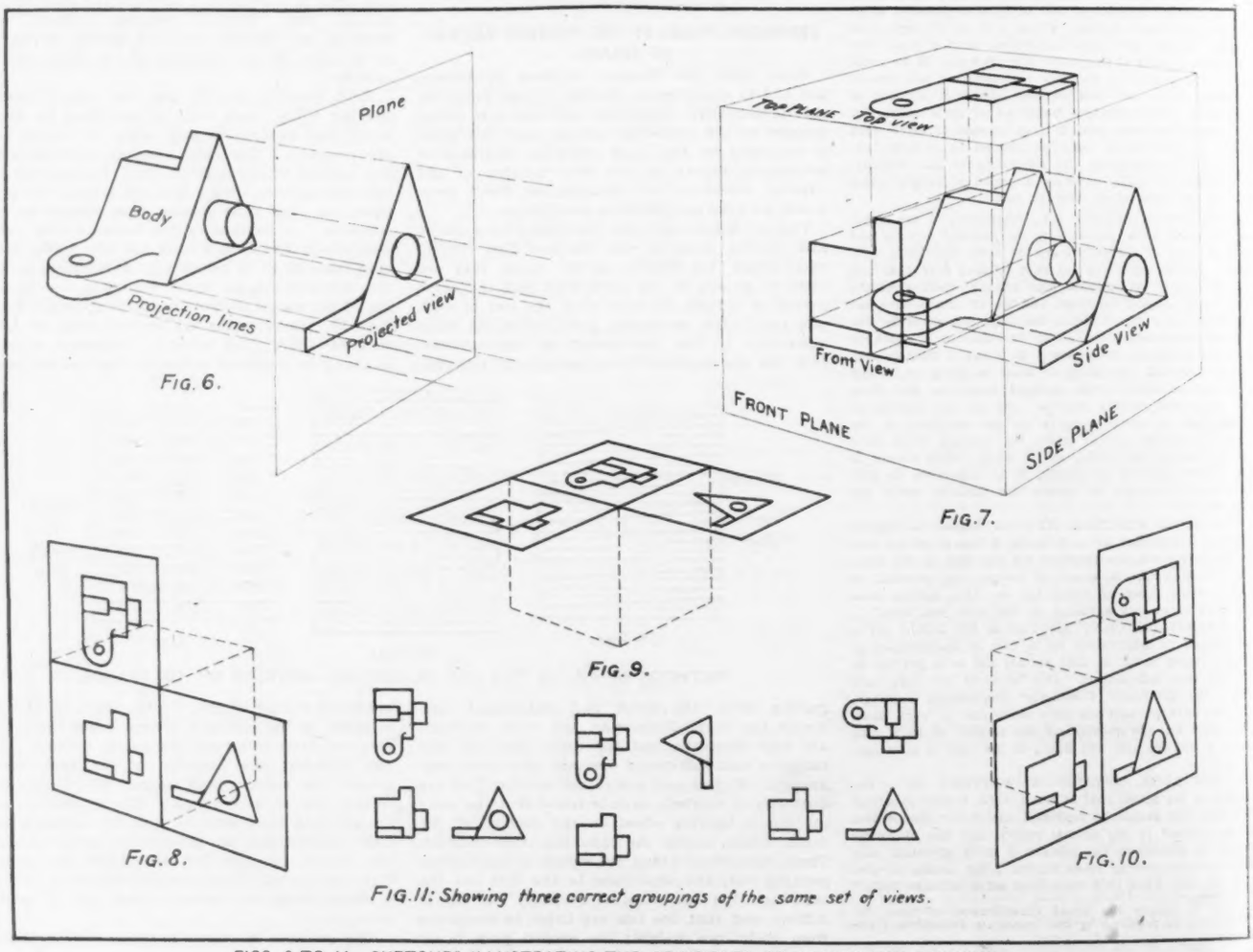

FIG. 6. FIG. 7.

FIG. 9.

FIG. 8. FIG. 10.

FIG. 11: Showing three correct groupings of the same set of views.

FIGS. 6 TO 11. SKETCHES ILLUSTRATING THE PRINCIPLES OF PROJECTION DRAWING.

side plane; and three projections, or views, are obtained, which it would obviously be correct to call a top view, a front view, and a side view, respectively.

53. In Fig. 8 the three planes with their views have been brought into one surface. This brings the "top" view "above" the front view, and the "right"-side view to the "right" of the front view; a correct grouping. Two other groupings, equally correct, are shown in Figs. 9 and 10; and all three are mechanically reproduced in Fig. 11. It is evident that each grouping embodies the same principle of projection, and has precisely the same meaning; it is also evident that Fig. 7 is a full and complete interpretation of each group.

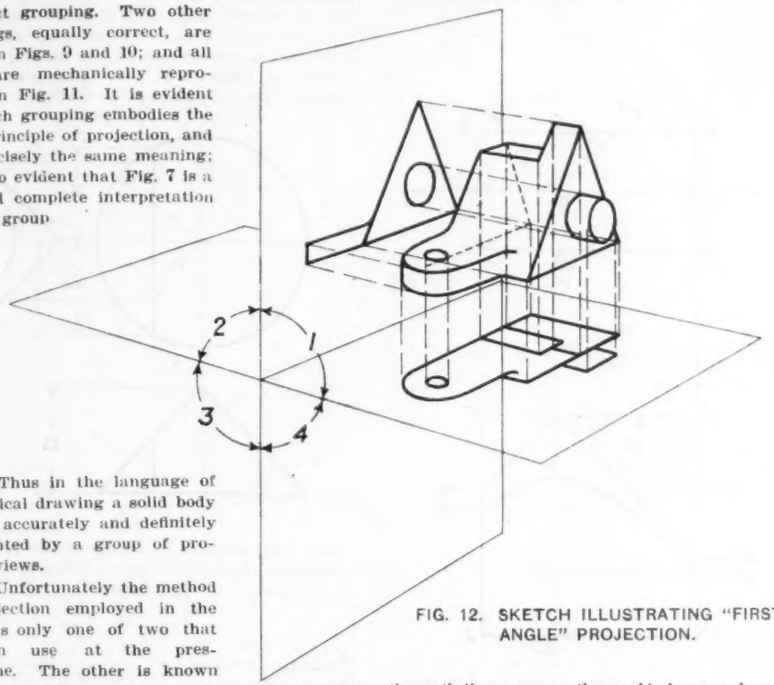

FIG. 12. SKETCH ILLUSTRATING "FIRST ANGLE" PROJECTION.

54. Thus in the language of mechanical drawing a solid body can be accurately and definitely represented by a group of projected views.

55. Unfortunately the method of projection employed in the above is only one of two that are in use at the present time. The other is known as "first angle" projection, and this "Dictionary" would be incomplete if it did not contain something akin to a definition of it. In geometry, when two planes intersect at right angles the angles are designated first, second, third and fourth, as numbered in Fig. 12. First angle projection places the body in angle No. 1 and projects a "top" view on to the plane "under" the body and a view of the "right" side on to the plane to the "left" of the body, and so on; that is, the projection lines instead of being "thrown out from the surface," are "passed back through the body." In other words, the body is supposed to turn itself inside out.

56. The absurdity of this method, clearly demonstrated by contrast in Fig. 13, led to its being entirely abandoned in this country, and it is to be hoped that the true method will eventually supersede it universally.

57. True projection is sometimes called "third angle" to distinguish it from "first angle." The name, however, is not only superfluous, but can easily be misleading, because no matter which "angle" the body is supposedly placed, in or how many planes are employed, if true projection is used the views will always be orthodox.

58. In a mechanical drawing every view should be projected in the orthodox manner, and correct grouping should never be sacrificed, on the plea of convenience, to any mere "arrangement." If it is impossible because of the shape or limited size of a drawing to project a view into its proper place, a special view may be drawn; but such a view must not be placed as though it were projected from others, but must be distinctly separate and independent, and be suitably titled.

59. In mechanical drawing a group of views is a complete and comprehensive "sentence" (Paragraph 6, Part 1) and if one of the group is where it should not be, it amounts not merely to an error in spelling, but to a misleading statement.

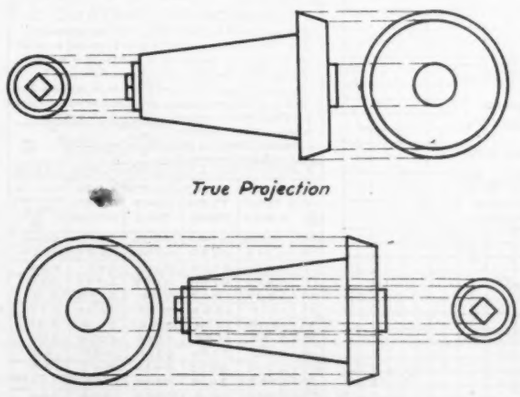

Fig. 13. First Angle Projection and True Projection Contrasted.

DIRT AS A SOURCE OF DISEASE.*

"Dirt," in the sense of human excrement, has been considered at length by Professor Sedgwick in an excellent series of articles, which have appeared in this journal for some months past. The present article considers dirt and dust in the more ordinary and usual meaning of those terms.

The objections to dirt and dust are three in number, the aesthetic or sensory, the psychical or moral, and the hygienic. The aesthetic objections are optical, as when agreeable colors or lines are obscured by dirt or dust; second, tactile, as when something feels gritty or greasy, which should not feel so; gustatory, as when one can "taste dust in the air;" olfactory, as when one smells decomposing dirt, and sometimes auditory, as when a machine purrs or clacks from dirt in the bearings. But dirt is simply matter out of place; the oil that on a pair of white kid gloves is "dirt," would be, in the bearings of a machine, a saving grace. Fresh morning dew mixed with a little pure sand or clay "dirties" one's shoes, and one proceeds to "clean" them by daubing them with a mixture of grease, soot, and often saliva, which, carefully smoothed by rubbing until it shines, is considered quite ornamental.

The psychical objections to dirt and dust lie chiefly in an association of ideas between dirt and dust on the one hand and carelessness, laxness and slip-shod methods on the other. A dirty man is objectionable from this standpoint because of the implication from his appearance that he is "sloppy" in other things as well. Yet a battle-stained hero fresh from the field is adored for the very dirt and dust with which he is covered, because in this case, the significance of the dirt is the reverse of its ordinary significance. The dirt and dust which on a locomotive engineer is a symbol of his responsible, and to some minds, even romantic, occupation, would, in the case of a banker, disqualify him for business.

The hygienic objections to dirt and dust are based on the external action of its particles in clogging the mouths of the ducts of excretory glands of the skin, irritating the eyes, producing chafing between skin surfaces in contact, etc., and their internal action, varying with the size, shape and material of which these particles are composed, from practically nothing to severe irritation, upon the mucous membrane of the nose, throat and lungs and intestines. Here the mere mechanical irritation, as in the case of fine sand, may produce severe discomfort. Certain chemical dusts may, by absorption, produce specific poisonings, and in any case, irritation set up in such ways, probably tends to make more easy the operation of harmful bacteria, if these should reach the irritated membranes. Bacteria of some form or other, generally harmless, sometimes, if the right conditions be provided, harmful, are likely to be present in the mouth, nose, throat and intestines of every one, and dirt or dust, not itself infected, may, on reaching the mucous membranes, irritate them sufficiently to permit the harmful action of bacteria already present there.

As distinct from the conditions outlined in the last paragraph, the actual transmission of disease through dust and dirt is probably the smallest and least important of all the objections to them. Dust and dirt can transmit disease only when infected, and infected dust and dirt forms only a very small proportion of the total dust and dirt in the world. Tuberculosis may sometimes be conveyed in this way. Garden mold (in some sections of the world), if admitted to some forms of wounds may give rise to lockjaw because the tetanus organism is in some places a normal inhabitant of the soil. Typhoid-infected excreta, transferred by food, drinks, or otherwise, to the mouth may transmit typhoid fever. But in general, the typical infectious diseases of the temperate zone, diphtheria, scarlet fever, tuberculosis, and the rarer smallpox, are not commonly conveyed otherwise than pretty directly from patient to patient. The older ideas that dirt and dust would or could in themselves generate disease is now quite as thoroughly exploded as the hypothesis of spontaneous generation. Dirt and dust are enemies to progress, refinement, civilization, and sometimes to health, but they do not in themselves propagate or even to any great extent transmit the ordinary infectious diseases. The presence of bacteria, when, as is usual, they do not belong to any of the specific disease-producing forms, adds no great objection to dust, for bacteria are present already in the nose, throat, etc., of every one, in milk, water, foods, etc. The degree of legitimate fear from the standpoint of infection with which any given aggregation of dirt or dust may properly be regarded, is proportionate entirely in each case to the number and kinds of opportunity of infection from diseased persons to which the particular dust or dirt in question has been exposed. To illustrate by reference to two extremes, the infectiveness of the dust and dirt of a crowded tubercular hospital ward is enormous compared with the dust and dirt of an Arizona desert. Of course, all intermediate grades of infectiveness occur.

Dirt, in the sense of human excreta, is like other dirt, dangerous only when infected. The safe rule to follow, however, is to consider all such excrement "guilty until it is proved innocent." In the case of the accumulated excreta of communities which constitutes "sewage," such an assumption is probably always more or less correct at some time or other. Since it is impossible to say of any given sewage at any given time that it is not infective, it is safest to regard it and handle it always as if it were infected.

*Editorial in the American Journal of Public Hygiene and Massachusetts Association of Boards of Health, Quarterly Number for May, 1905.

A PROBLEM IN THE STORAGE OF GRANULAR AND LUMP MATERIAL.

By W. E. Hunter* and J. S. Myers.†

It is a well-known fact that certain kinds of material, dropped from a fixed point of discharge, will, depending upon the material, assume definite angles of repose which are notably uniform in slope over the surface of the pile, rendering the computation of a close approximation to the contents of the pile, or weight of the material, an easy matter.

This angle of repose, P, see Fig. 1, is for anthracite coal, 27°; for bituminous coal, 40°; for dry sand, 33°; etc. Often, however, the piles, whether in the open or under cover, are confined at the base by vertical retaining walls, thereby destroying the symmetry of the natural conical shape, and the amount of this confinement may

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vary from the single vertical wall placed at one side to complete enclosure of the base by four such retaining walls forming a rectangle. To compute the contents of the pile of material under these circumstances becomes one of some difficulty if necessary to resort to an elementary calculation, consequently it is customary to use approximation methods for the purpose, and while it may be conceded that the approximation methods are sufficiently accurate, the diagrams, herewith exhibited, have the merit of not only greater accuracy, but also of affording greater expedition in practice. The probability of error is likewise minimized.

In Fig. 1, which is the representation of a conical pile enclosed at the base by four retaining walls, with the apex, O, midway between the walls, C' C and B' B, it is seen that the solid within one quadrant is made up of a parallelopiped having the base, O L C D and altitude I H, and also that portion of the quarter-cone within the walls having its apex at O in plan and O' in elevation and altitude J O'. It is therefore necessary to obtain the contents of the two portions of the quarter-cone cut off by the walls C' C and C B, having the bases C L F and D C E and altitudes H G and J K, so that these volumes may be subtracted from the contents of the quarter-cone.

The mathematical treatment in a condensed form is as follows:

Referring to Fig. 2:

Let a = altitude of cone;
r = radius of base of cone;
z = distance from axis of cone to cutting plane; given in Fig. as Z_1 Suscript dropped for simplicity.
V = volume of entire cone;
v = volume of portion cut off by plane.

We have,

$$x^2 + y^2 = R^2, \text{ and } R : x :: r : a;$$

$$\text{therefore } y = \sqrt{\frac{r^2 x^2}{a^2} - z^2} = \frac{r}{a}\sqrt{x^2 - \frac{a^2 z^2}{r^2}}$$

$$\text{and } v = \frac{2r}{a}\int_{\frac{a}{r}z}^{a}\int_{z}^{r}\left(x^2 - \frac{a^2 z^2}{r^2}\right)^{\frac{1}{2}} dx\, dz =$$

$$\int_{z}^{r}\left[a\,(r^2 - z^2)^{\frac{2}{2}} - \frac{a z^2}{r}\log_e\frac{r + \sqrt{r^2 - z^2}}{z}\right] dz =$$

$$\frac{a r^2 \pi}{4} - \frac{2 a z \sqrt{r^2 - z^2}}{3} - \frac{a r^2}{2}\arcsin\frac{z}{r} + \frac{a z^3}{3r}\log_e \frac{r + \sqrt{r^2 - z^2}}{z} - \frac{a r^2}{6}\arccos\frac{z}{r}.$$

The characteristics of each of these terms of v are given in Diagram A, both positive and negative terms, for economy of space, being placed above the zero line. The curve designated $\frac{v}{V}$ gives the proportion of the volume severed from

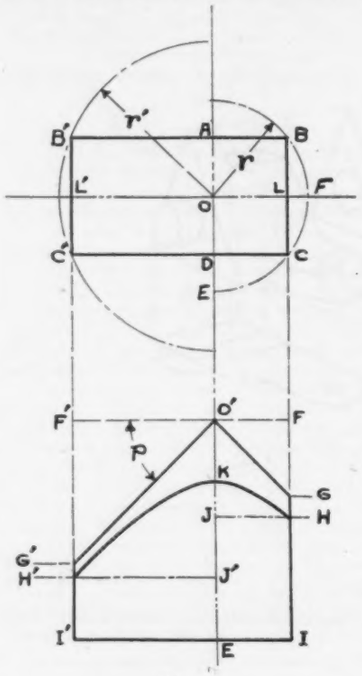


Fig. 1.

the cone to the volume of the entire cone. This ratio is constant for the corresponding ratio $\frac{z}{r}$, irrespective of the dimensions a and r, consequently it is only necessary to obtain the volume of the whole cone and multiply it by this ratio as given in the table or from the curve, and the volume of the portion severed is arrived at. For instance if it is desired to obtain the contents of that portion of a cone remaining from which has been removed a part exterior to a cutting plane situated midway between the axis and the outer extremity of the base, we first ascertain that the ratio $\frac{z}{r} = .50$, and a reference to the diagram shows that the ratio of the part cut off is, to the entire cone, .110.

Diagram A and the table accompanying it were not worked out with more accuracy than may be obtained by means of the ordinary slide-rule, as the writers, desiring a diagram more suitable to rectangular bins, were agreeably surprised to find that a combination of two cutting planes as shown in Diagram B, very much simplified the formula for purposes of calculation. This formula was obtained by means of the proper substitutions, displacing z by its value as a function of the angle ϕ, in the following:

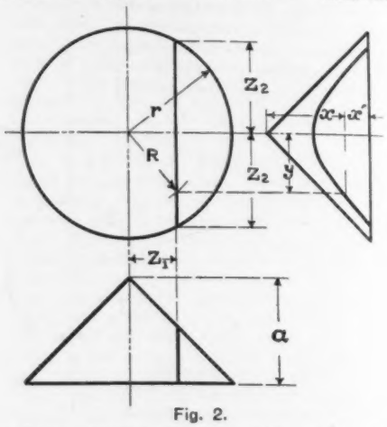


Fig. 2.

$$\frac{v}{2} - v_1 - v_2 = \frac{a r^2}{3}$$

$$\left[2\sin 2\phi - \cos^3\phi \log_e \tan\frac{90^\circ + \phi}{2} - \sin^3\phi \log_e \cot\frac{\phi}{2}.\right]$$

Making a and r each equal to unity in the above formula gives the formula for the unit semi-cone. This unit value C_1 was used in plotting Diagram B, and is shown thereon. The solution was made for the semi-cone as it is not always practicable to have the apex at the geometrical center of the bin. The formula and curve may be as readily used in the case where the apex is not placed centrally in either direction by taking one-half the reading of the curve which then applies to a quarter-cone. Formula C_1 may also be transformed to give tons or bushels as desired by multiplying it by the proper constants for the material forming the cone. The values of C_1 given to five decimal places were calculated, intermediate values being readily interpolated from the curve.

Table B gives values of C_1 corresponding to values of $\frac{Z_2}{Z_1} = .36$ to 1.00, advancing by .02 interpolated from the curve. The column headed P gives the proportion of the volume remaining to the volume of the semi-cone. The column headed C_2 gives the coefficient by which to multiply r^3 to obtain volume when the material stored is anthracite coal, the angle of repose of which is 27°. This table covers the range for practical purposes as it would not be economical to construct bins under ordinary circumstances with a width less than about 0.5 to 0.6 of the length. In use the reading of Diagram A should be multiplied by the contents of the complete cone and the product subtracted from the entire contents; the reading of Diagram B should be multiplied by the product of the altitude and the square of the radius of the base, the result will be the contents of the semi-cone within the bin, and this result divided by two will give the contents of the quarter-cone within the bin.

EXAMPLE.

A bin for anthracite coal is 230 by 160 ft. and the apex of the cone is at the cen-

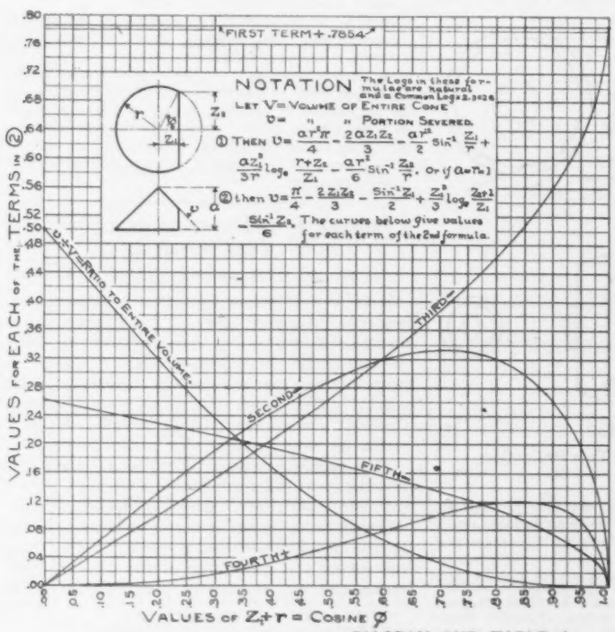

FIRST TERM = .7854
NOTATION
The Logs in these formulae are natural and a Common Log = 2.3026
LET V = VOLUME OF ENTIRE CONE
v = " " PORTION SEVERED.
① THEN v = $\frac{a r^2 \pi}{4} - \frac{2 a z_1 z_2}{3} - \frac{a r^2}{2}\sin^{-1}\frac{z_1}{r} + \frac{a z_1^3}{3 r^2}\log_e\frac{r + z_2}{z_1} - \frac{a r^2}{6}\sin^{-1}\frac{z_2}{r}$. Or if a = r =1
② then v = $\frac{\pi}{4} - \frac{2 z_1 z_2}{3} - \frac{\sin^{-1} z_1}{2} + \frac{z_1^3}{3}\log_e\frac{z_2 + 1}{z_1} - \frac{\sin^{-1} z_2}{6}$
The curves below give values for each term of the 2nd formula.
Z_1
Z_2
r
a
v
VALUES FOR EACH OF THE TERMS IN ②
VALUES OF $Z_2 \div r$ = COSINE ϕ
THIRD
SECOND
FIFTH
FOURTH
$\frac{v}{V}$ = RATIO TO ENTIRE VOLUME.

DIAGRAM AND TABLE A.

CO-ORDINATE DISTANCES

For each of the terms in the expression for the volume of the portion of a cone severed by passing a cutting plane parallel to the axis, from Formula 2. By inserting all the coefficients in formula 2 the 3rd and 5th terms summate. Let a = r = 1 as before, let ϕ = angle in degrees; formula 2 then becomes $v = .7854 - \frac{\sin 2\phi}{3} - .00582(135 - \phi) + 2.3026\frac{\cos^3\phi}{3}\log\frac{1 + \sin\phi}{\cos\phi}$. ⑤

Logs in ① are common Logs.

FIRST TERM IS CONSTANT = $\pi/4$ = .7854

VALUE $\frac{Z_2}{r}$	SECOND TERM MINUS	THIRD TERM MINUS	FOURTH TERM PLUS	FIFTH TERM MINUS	RATIO TO ENTIRE CONE = $\frac{v}{V}$
.00	.0000	.0000	.0000	.2618	.5000
.05	.0333	.0250	.00015	.2535	.4524
.10	.0664	.0504	.0010	.2451	.406
.15	.0970	.0754	.0029	.2368	.362
.20	.1297	.1007	.0061	.2286	.318
.25	.1617	.1264	.0107	.2200	.277
.30	.1909	.1524	.0166	.2116	.237
.35	.2170	.1787	.0230	.2026	.201
.40	.2445	.2056	.0335	.1930	.166
.45	.2682	.2333	.0434	.1842	.137
.50	.2887	.2618	.0548	.1745	.11007†
.55	.3064	.2910	.0668	.1648	.086
.60	.3200	.3216	.0790	.1547	.065
.65	.3291	.3538	.0914	.1442	.047
.70	.3330	.3880	.1020	.1325	.032
.707	.3333	.3927	.1059	.1309	.03086†
.75	.3306	.4246	.1118	.1204	.021
.80	.3202	.4640	.1183	.1074	.012
.85	.2982	.5080	.1200	.0924	.007
.90					*
.95					*
1.00	.0000	.7854	.0000	.0000	.0000

* SLIDE RULE NOT ACCURATE ENOUGH FOR THESE
† SOLVED BY SIX PLACE LOGS

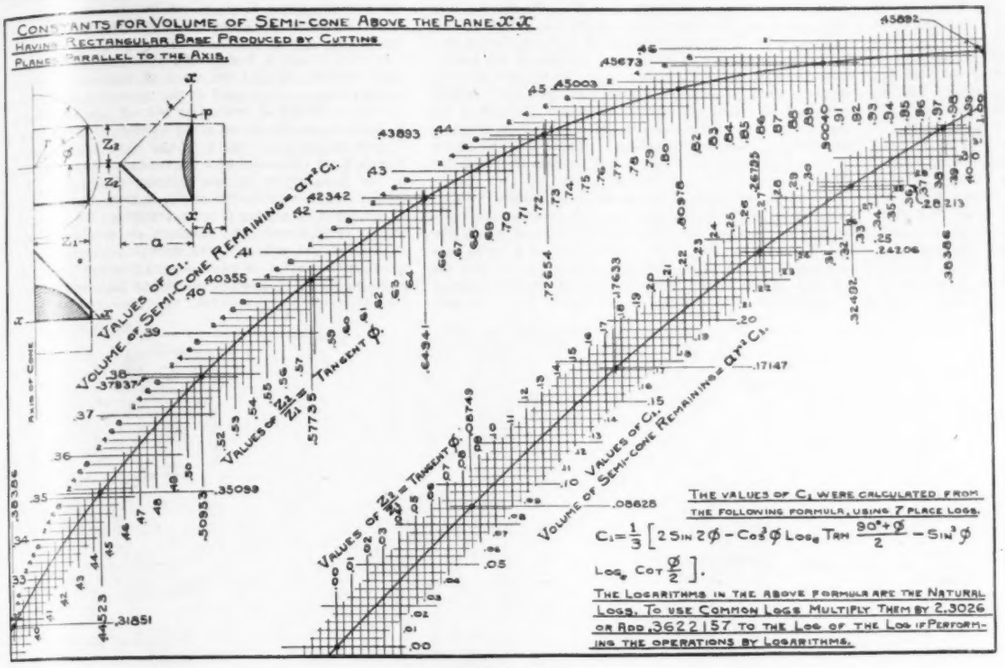

CONSTANTS FOR VOLUME OF SEMI-CONE ABOVE THE PLANE X X
HAVING RECTANGULAR BASE PRODUCED BY CUTTING PLANES PARALLEL TO THE AXIS.
VALUES OF SEMI-CONE REMAINING = a r² C₁.
VALUES OF C₁.
VOLUME OF SEMI-CONE
TANGENT φ.
VALUES OF Z₁/r = TANGENT φ.
VOLUME OF SEMI-CONE REMAINING = a r² C₁.
THE VALUES OF C₁ WERE CALCULATED FROM THE FOLLOWING FORMULA, USING 7 PLACE LOGS.
C₁ = 1/3 [2 Sin 2φ − Cos²φ Log_e Tan (90°+φ)/2 − Sin²φ Log_e Cot φ/2].
THE LOGARITHMS IN THE ABOVE FORMULA ARE THE NATURAL LOGS. TO USE COMMON LOGS MULTIPLY THEM BY 2.3026 OR ROD. 3622157 TO THE LOG OF THE LOG IS PERFORMING THE OPERATIONS BY LOGARITHMS.

DIAGRAM B.

ter of the building and 80 ft. and 8 ins. from the floor. Required the capacity of the bin.

$z_1 = 115$, $z_2 = 80$, $r = \sqrt{z_1^2 + z_2^2}$, and $a = r \tan 27°$.

$(115)^2 = 13{,}225$
$(80)^2 = 6{,}400$
$r^2 = 19{,}625$
log r^2..... 4.2928079
log r..... 2.1464040
log tan 27° 9.7071659

$\frac{z_1}{z_2} = \frac{80}{115} = .695$, hence C_1 from curve = .4332 and
log C_1..... 9.6366884

Log V_2..... 5.7830680 and V_2 = 606.830 cu. ft.
and 2 V_2 = 1,213,660 "
log r..... 2.1464040
log tan 27° 9.7071659
log a..... 1.8535699 a = 71.379

80.667
71.379
9.288

log 9.288.. .9184479
log 160.. 2.2041200
log 230.. 2.3617278
5.4842975

therefore, contents of parallelopiped is equal to 305,000 cu. ft.
contents of conical pile..... 1,213,660 "
contents of the bin..... 1,518,660 cu. ft

This amount multiplied by $\frac{52}{2{,}000}$ = 39,485 tons, the required capacity in tons of 2,000 lbs., taking the weight as 52 lbs. per cu. ft.

ELECTRICAL DEVICES FOR DEEP BOREHOLE SURVEYING.*

By Hugh F. Marriott.

In this paper I will first describe in detail the construction of the two sets of instruments I have lately perfected for use in deep level borehole surveying, and will then give some of the results which have been obtained by this apparatus, showing the extreme value of the information gained thereby.

The instruments in their present form are the outcome of many years' experience and numerous experiments with various forms of apparatus of both mechanical and chemical action.

It would require a long historical sketch to enumerate all the points of failure that were encountered and noted, and it will be sufficient for this purpose to say that the results obtained by the various experiments showed that a workable instrument to give reliable information of the course of a borehole must fulfil the two following requirements:

In a continuously working instrument the operator must know what changes are being recorded by the instrument at the same time that such changes take place.

In an intermittently working instrument the operator must be able to absolutely unlock and lock the recording apparatus at will at the point at which it is required to take readings.

The various forms of secondary apparatus made to record the readings to be afterwards read in their turn by the operator on the surface, if made of a sufficient standard of accuracy to work well in the laboratory, are of too delicate a nature to withstand the necessarily rough treatment they must be subjected to while being lowered or raised in a borehole.

For this reason, I therefore finally turned to electricity as the only means of fulfilling the stringent requirements the circumstances demanded.

*A paper read before the Institution of Mining and Metallurgy, Feb. 16, 1905.

CONSTANTS FOR VOLUME OF SEMI-CONES
HAVING RECTANGULAR BASE PRODUCED BY CUTTING PLANES PARALLEL TO THE AXIS.
VALUES MARKED * WERE CALCULATED WITH SIX PLACE LOGS.
FORMULA DEVELOPED BY W.E. HUNTER APPLIED BY J.S. MYERS.

$a = r \tan p$. $p = 27°$ for Anthracite Coal, $= 40°$ for Bituminous Coal, $= 33°$ for Dry Sand
Let U = Volume of Semi Cone Above the plane X X Bounded by the Planes Parallel to the Axis Which are Distant from that Axis, Z_1 and Z_2 Respectively; P = U + Volume of Semi Cone

$$U = \frac{a r^2}{3}\left[2 \sin(2\phi) - \cos^2\phi \log_e \tan \frac{(90° + \phi)}{2} - \sin^2\phi \log_e \cot \frac{\phi}{2}\right]$$

or $U = C_1 a r^2$. For $P = 27°$, $U = C_2 r^3$. $C_{1.509525} C_1$

φ	Z_2+Z_1	C_1	C_2	P	φ	Z_2+Z_1	C_1	C_2	P
	.36	.305	.155	.583		.72	.438	.223	.837
	.38	.317	.161	.606	36°	.7265*	.4389*	.2236*	.839
	.40	.328	.167	.627		.74	.441	.225	.843
	.42	.339	.173	.648		.76	.444	.226	.848
	.44	.349	.178	.667		.78	.447	.228	.854
24°	.4452*	.3510*	.1788*	.671		.80	.449	.229	.858
	.46	.358	.182	.686	39°	.8098*	.4500*	.2298*	.860
	.48	.367	.187	.701		.82	.451	.230	.862
	.50	.376	.192	.718		.84	.453	.231	.865
27°	.5095*	.3794*	.1935*	.725		.86	.4546	.2315	.868
	.52	.383	.195	.732		.88	.4557	.2320	.870
	.54	.391	.199	.747	42°	.9004*	.4567*	.2327*	.872
	.56	.398	.203	.760		.92	.4578	.2332	.874
30°	.5774*	.4035*	.2056*	.770		.94	.4583	.2335	.875
	.58	.404	.206	.772		.96	.4586	.2336	.876
	.60	.410	.209	.783		.98	.4586	.2337	.877
	.62	.416	.212	.795	45°	1.00*	.4589*	.2336*	.877
	.64	.421	.214	.804	The logarithms in the above formula are the Natural Logarithms. To use Common Logs multiply them by 2.3026				
33°	.6494*	.4234*	.2157*	.809					
	.66	.425	.216	.812					
	.68	.429	.218	.820					
	.70	.434	.221	.829					

VOLUME OF SEMI-CONE REMAINING = a r² C₁ = .5236

Table B.

The instruments heretofore employed for the purposes specified have chiefly been designed to take indications or readings by means of liquids which solidify on cooling or solidify by time, and thereby fix the indicators in the positions which they assume at the point to be surveyed. These instruments have proved inadequate for obtaining accurate results, owing to the greater depths to which the boreholes are now made.

The instruments in which liquids solidifying by cooling are employed have not proved satisfactory at depths exceeding 1,000 ft. or thereabouts, owing to the extremely rapid cooling effect of the water in the borehole through which the instrument must pass in lowering it to the desired position. The instruments in which the liquids solidifying by time have been employed are a convenient method for obtaining the desired results, but a reliable liquid or solution suitable for the purpose has not been found. The use of liquids solidifying by time has hitherto proved too unreliable and erratic to be of much value. Further, with the existing instruments it has only been possible to obtain intermittent readings, that is to say, it has been necessary to take one indication, then to remove the instrument from the borehole and read it, then to lower the instrument into another position to obtain another indication, after which it is again removed in order to read the second indication, and so on until the necessary data or information has been obtained.

Now the object of my invention is to produce an instrument in which electricity may be employed for obtaining the desired information, whereby a complete and continuous reading may be obtained as the instrument is lowered down the borehole, which reading may be checked or verified as the instrument is withdrawn from the borehole.

The invention will now be described in detail by aid of the accompanying drawings.

Similar letters of reference indicate the same or corresponding parts in the several figures of the drawings.

Fig. 1 is a vertical section of the instrument.

Fig. 2 is a diagrammatic sketch of the electrical connections.

Fig. 3 is a diagrammatic sketch of an alternative arrangement of the electrical connections.

Fig. 4 is a vertical section of the cable head.

Fig. 5 is a section of the lower portion of the cable head, showing the connections with the conductors for the current.

Fig. 6 is a plan of the lower end of the cable head.

Fig. 7 is a sectional elevation of a slightly modified arrangement.

Referring to Fig. 1, A represents an external cylindrical casing or tube, which may be made of hardened gun-metal, or any other suitable material sufficiently thick to effectually withstand the maximum pressure to which it is likely to be subjected when lowered into the borehole.

Inside the tube A is arranged a hollow hemi-cylinder B of brass, or other suitable metal, which is arranged and supported perpendicularly inside the casing A on two pivot pins or screws, b, b^1, so that when the casing A is in a vertical position the movement of the hemi-cylinder B, or interior of the pivoted portion, is truly horizontal. Metal plates or disks, a, a^1, which are secured by means of screws, a^2, a^3, screwed through the casing A, serve for carrying the pivot screws, b, b^1. The pivot screw b^1, in the bottom disk a^1, is insulated by means of a bush, a^{1a}, of ebonite or other suitable insulating material.

In the ends of the hemi-cylinder B are fixed disks, b^2, b^3. In the top disk, b^2, is fixed a screw, b^4, insulated from the disk by means of the ebonite bush b^2. The screw, b^4, at its upper end is formed with a hole, into which the pivot screw b projects. The head of the screw b^4 serves for attaching below the bush, b^5, a metal disk or plate, a^4. In the disk, b^3, at the other end of the hemi-cylinder B, is fixed the screw b^6, which at its lower end is formed with a recess into which the pivot screw b^1 projects. The pivot screws, b, b^1, serve for attaching the metal plates or disks, a^5, a^6, to the disks, a, a^1.

In the upper end of the tube A is fixed an ebonite disk, C, which carries the two contact rings, c, c^1. This disk C may be secured by means of screws, c^2, screwed into it through the casing.

In the inside of the hemi-cylinder B, are fixed brackets, D, D^1, which carry or support a vertically arranged rod or bar, E. To the lower end of this bar E is pivoted a weight or plumb-bob, F, which is attached to the rod E in such a manner that it can swing freely in one plane only.

Attached to the top of the plumb-bob F is a switch arm G, which carries at its upper end a strip of platinum. The movement of the plumb-bob F causes the switch-arm G to describe an arc or radial path about the pivot f, or

A CONTINUOUSLY RECORDING INSTRUMENT FOR DETERMINING DIP IN A BOREHOLE.

This invention relates to means for surveying boreholes, and more particularly to an instrument for determining the amount of dip.

center of oscillation, of the plumb-bob F. Fixed to the vertical rod E is a commutator H, upon which the platinum upper end of the switch-arm G presses gently. The commutator H consists of numerous platinum contacts h, interspaced with ebonite pieces h^1, or other suitable insulating material placed at equal distances apart. Carried by the rod E above the commutator H is a resistance coil J, which is connected up with the commutator H.

The commutator H may, as shown in Fig. 2, be connected up with the resistance coil J; so that the movement of the switch-arm G first makes a free current, then a blank, then a resistance, then a blank, then a free current, then a blank, then a resistance, and so on; or it may be arranged, as shown in Fig. 3, to start from a normal position with a maximum resistance, and gradually, as the switch-arm G passes over the commutator H, cut out the resistance; or, alternately, start from a minimum resistance and gradually increase to the maximum resistance with each successive segment, that is to say, it may be arranged either to cut the resistance in or out, each segment of the resistance being preferably interspaced with a blank.

The two wires or conductors K, L, which serve for passing the current of electricity through the instrument, may be connected up with a series of primary or secondary cells of ascertained electro-motive force, a galvanometer, and a standard resistance box. The various resistances of the coil having been previously compared with those of the standard resistance box, the declination of the plumb-bob F from the vertical can always be ascertained by means of the galvanometer.

The wire k from the concentric ring or terminal c in the top of the casing A is attached to the top pivot screw b through the medium of the plate or disk a^5. This allows the current to pass from the terminal c through the pivot screw b to the screw b^4 and disk or plate a^3. This latter disk or plate, a^4, is connected to the resistance coil J by means of the wire k^1. The wire k^2 from the other terminal c^1 is preferably insulated and located in a groove in the casing and attached to the disk or plate a^5 fixed to the lower pivot screw b^1 so that the current may pass through the lower pivot screw b^1, screw b^2 and hemi-cylinder B to the plumb-bob F and switch-arm G.

The hemi-cylinder B, or pivoted portion of the instrument, is weighted with segments M, M^1 of lead or other material fixed in suitable positions so that their weight, combined with that of the main portion of the rest of the instrument, operates when the outer case A is tilted in any direction to revolve the hemi-cylinder B on its pivots b, b^1 and to bring it to rest in the position in which the switch-arm G moves in a vertical plane.

The upper extremity of the casing A is provided with an internal screw-thread m, into which is screwed the cable head which serves for attaching the instrument to the end of the cable. The cable head consists of a lower part or plug N, which in its lower portion is formed with an external screw thread n corresponding to the internal screw thread m in the top of the casing A. It is also preferably formed externally with a part n^1 of hexagonal or other suitable shape for screwing it into the upper end of the casing A. This part of the head is constructed with an internal recess n^2 for packing so as to make a water-tight joint round the cable O, and to prevent the ingress of water into the casing A through the cable head. Inside the recess n^2, round the cable O, is arranged a ring n^3. This ring n^3 on the inside is made conical so that as it is forced down it compresses the packing tightly into the recess n^2 round the cable O. The upper end of this plug N is formed with an internal screw-thread n^4, into which is screwed the gland-nut P which serves for forcing down the ring n^3 to close the packing tightly round the cable. The upper end of the plug N is also formed with an external screw-thread n^5, over which is screwed the cap or nut Q. Inside the cap Q, above the top of the gland nut P, are arranged four (more or less) gripping pieces R, which serve to grip and attach the cable head and instrument to the cable O. The gripping pieces R are formed with conical extremities fitting a conical recess r in the top of the gland nut P at the lower end, and projecting into a ring r^1 at the upper end. By screwing down the cap Q the gripping pieces R are forced inward between the [illegible] r^1 in the top of the gland nut P and thereby firmly [illegible] the cable.

In Figs. 5 and 6, I show the attachments fitted [illegible] cable head for making the electrical connections with [illegible] contact rings c, c^1, located in the upper end of the [illegible] A. These consist of two spring contact pins or terminals S, fixed in an ebonite or other suitable plug or bush [illegible], carried by the lower end N of the cable head. These terminals S are connected with the conductors or wires [illegible] in any ordinary or suitable manner. In Fig. 7, I illustrate a slight modification of the instrument, which may be employed to render it more sensitive. In this case I employ three plumb-bobs F, which are pivotally attached to the vertical rod E. The several plumb-bobs F are pivotally connected to each other by means of the connecting rods F^1. Instead of employing three of the plumb-bobs F, it will be obvious that two, four or more [illegible]

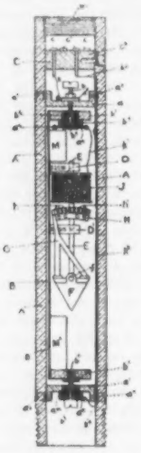


Fig. 1.

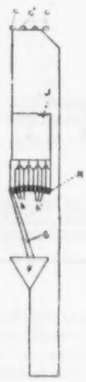


Fig. 2.

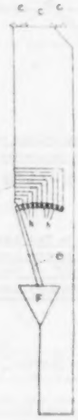


Fig. 3.

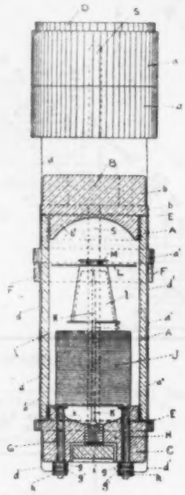


Fig. 8.

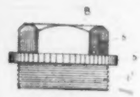


Fig. 9.

Fig. 10.

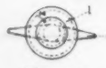


Fig. 11.

Fig. 12.

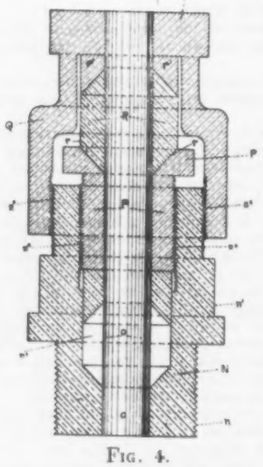


Fig. 4.

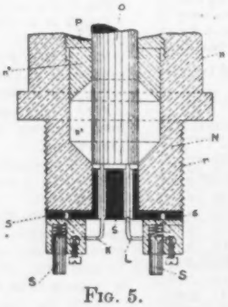


Fig. 5.

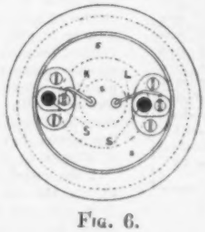


Fig. 6.

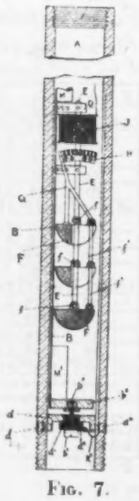


Fig. 7.

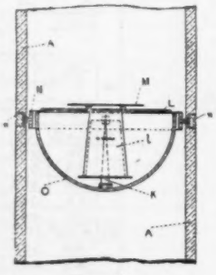


Fig. 13.

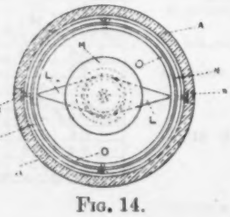


Fig. 14.

Fig. 15.

Fig. 16.

Fig. 17.

used. The other parts of the instrument are similar to those described with reference to Fig. 1.

AN INTERMITTENTLY RECORDING INSTRUMENT FOR DETERMINING DIP IN A BOREHOLE.

The object of this invention is to produce an instrument in which electricity may be employed for obtaining the desired information, and the invention consists essentially in the use of electricity as a means for liquefying a solid for recording readings *in situ*. By this means I find that I eliminate all error while the instrument is in motion or being raised or lowered in the borehole to be surveyed.

The invention will now be described by aid of the accompanying drawings, wherein—

Fig. 8 represents the instrument, removed from its casing, in part sectional elevation.

Fig. 9 is an elevation of the top screw cap or plug.

Fig. 10 is a plan of Fig. 9.

Fig. 11 is a plan of the magnetic compass and mirror, detached.

Fig. 12 is a plan of the resistance frame or coil, also detached.

Fig. 12 is a sectional elevation of a modified form of the instrument, drawn to an enlarged scale.

Fig. 14 is a plan of Fig. 13.

Fig. 15 is a part sectional elevation of the tubular or cylindrical casing for the instrument.

Fig. 16 is a transverse section of line x—x Fig. 15, and Fig. 17 is a plan of the cap or plug for closing the lower end of the casing.

Referring to Figs. 8 to 12 illustrative of the instrument, which are drawn to an enlarged scale, A represents a hollow cylinder or tubular vessel, which may be made of copper, or any other suitable material, fitted at the upper end with the screw cap or plug B, which latter is shown in detail in Figs. 9 and 10. It comprises the upper hexagonal portion b, the central cylindrical part b^1, and the externally-screwed lower portion b^2, which latter screws into the internally-screwed upper end of the tube A, as shown in Fig. 8. In the other and lower end of the tube A is screwed another cap or plug, C, similar in construction to the plug B.

Between the flanges of the caps or plugs B, C and the ends of the tube A, washers E of lead or other suitable material may be arranged.

The upper end of the tube A may be formed with an external annular projection or flange a^6, the diameter of which is slightly less than the internal diameter of the casing for the instrument, so that when the latter is placed in the former it serves to prevent lateral movement of the instrument inside the casing.

Above the top cap or plug B are arranged two cylindrical pieces a, a^1 of ebonite or other suitable non-conducting material. On the top of the ebonite piece a are secured two concentric rings D of brass or other suitable metal. To one of the rings D is attached the wire d, and to the other ring is connected the wire d^1. The wires d, d^1 pass through holes formed through the ebonite pieces a, a^1, and are electrically connected with the two rings D in any suitable manner. Contact is made with spring contact pins or other suitable means which serve for passing the current of electricity through the instrument.

In the exterior of the tube A, and diametrically opposite each other, are formed two longitudinal and vertical grooves a^2, a^3, in which the wires d, d^1 are located. Grooves a^4, a^5 (see Fig. 10) are formed in the flanges of each of the caps or plugs B, C, which grooves are brought into coincidence with the longitudinal grooves a^2, a^3 in the tube A, so that the wires d, d^1 lie in the grooves and are thereby removed from the surface or circumference of the tube A and plugs B, C. The wires d, d^1 are insulated from the tube A and the two plugs B, C.

Surrounding the tube A below the annular projection a^5 is secured a ring F, which serves for keeping the wires d, d^1 in position in the grooves a^2, a^3 in the tube A.

Located in holes formed through the cap or plug C are two terminals G, H, which are insulated from the plug C. On the outer ends of each of the terminals G, H and next the plug C is arranged a washer g of insulating material. Next the washer g is screwed a nut g^1. The one wire a^2 is connected with the terminal G and the other wire a^3 is connected to the other terminal H. h, h are nuts screwed over the lower extremities of the pins or terminals G, H which serve for making contact between the terminals G, H and the wires a^2, a^3, or for retaining the contacts in position.

Arranged in the lower portion of the tube A is a resistance frame or coil or spiral wire J. To this resistance frame J are attached the terminals G, H.

To the bottom cap or plug C is rigidly affixed a vertically disposed needle K which protects through the resistance frame J into the upper portion of the tube A. The needle K is formed with a screw thread which screws through a hole k tapped through the center of the bottom cap or plug C. On the other extremity of the needle K is formed or fitted a nut or head k^1 which serves for screwing the needle K through the cap or plug C when assembling the parts of the instrument.

Balanced on the point of the needle K is a magnetic compass L. The compass L is affixed to a conical or bell-shaped base I, which is made hollow on the underside and into which projects the upper end of the needle K. Fixed to the top of the compass L in a horizontal position is a small silver mirror M.

In Figs. 13 and 14 I illustrate the adaptation of an ordinary marine compass attachment for the arrangement shown in Fig. 8. The outer ring N of this attachment is pivotally carried by the screw n, screwed through the tube A. To the inner and concentric ring O of the attachment is attached a semi-circular band o which supports the vertical needle K, on the upper end of which the compass L is balanced. The compass L is similar in construction to that described with reference to the preceded arrangement.

In Figs. 15, 16 and 17, which are drawn one-third full size, I illustrate the cylindrical casing for the instrument illustrated in Figs. 8 to 12. This casing P consists of a hardened gun-metal or other suitable tubing made sufficiently thick to effectually withstand the greatest pressure to which it is likely to be subjected. In the lower

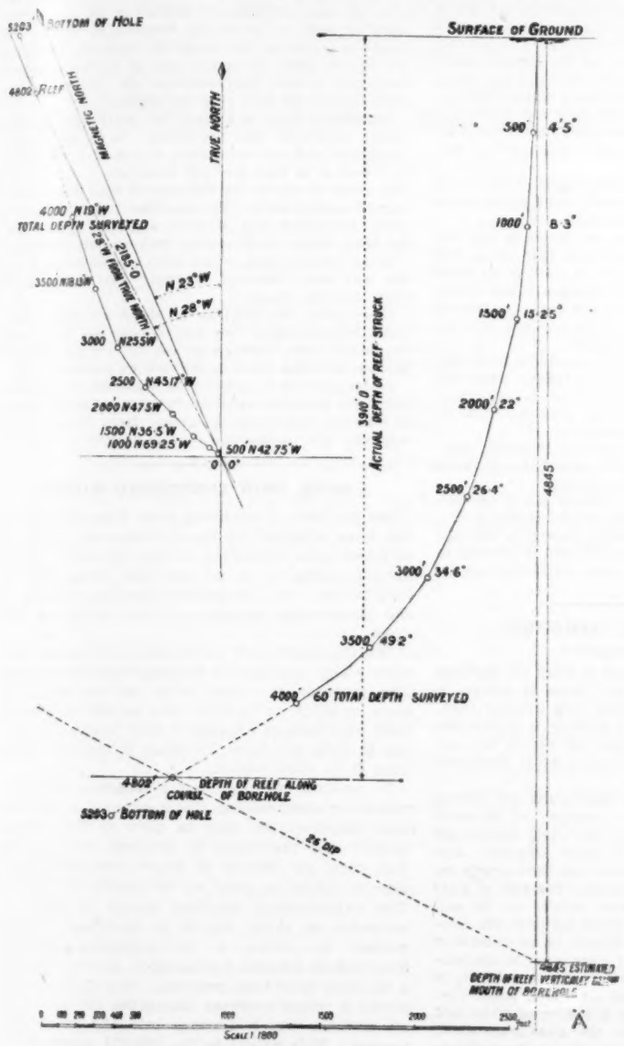


Fig. 18.

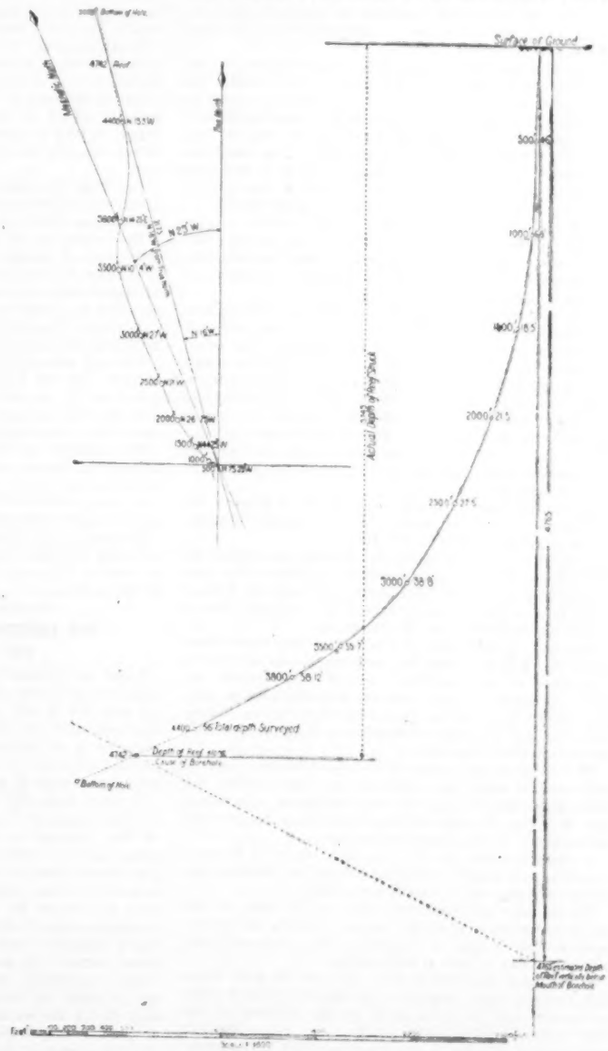

Surface of Ground
Actual depth of reef struck
Total depth Surveyed
Depth of reef along course of Borehole
Bottom of Hole

Fig. 19.

end of the casing P is screwed a plug p which serves for closing the lower end of the casing. To prevent the ingress of water a flange p^1 may be formed on the plug p, between which and the lower end of the casing P a washer p^2 of lead or other suitable material is preferably placed. The lower end of the casing P may be formed with flat surfaces p^3 for holding the casing by means of a spanner whilst screwing in the plug p. The plug p is formed with an eyepiece p^4 to allow of a weight being attached to the casing if desired, or any other instrument or attachment. The casing P is constructed with a longitudinal feather or projection p^5, and in proximity to its lower end it is formed or fitted with a diaphragm R. The upper end of the casing P is provided with an internal screw thread which serves as the means for attaching the piece or connection carrying the spring contacts which make contact with the concentric rings D (see Fig. 8).

The tube A, the screw caps or plugs B, C, and the ebonite pieces a, a^1, are formed with a vertical groove S (see Figs. 8 and 10), into which the feather p^5 projects to retain the instrument in position in the casing P. The instrument is lowered in the casing P until the bottom

cap or plug C rests upon the diaphragm R, by which it is supported.

After the magnetic compass L has been arranged in position on the needle K, which forms the pivot, molten paraffin wax, or other suitable material, is then poured into the tube until the lower portion of the compass attachment is well below the surface. The wax is then allowed to solidify, the top cap or plug B screwed into position, and the instrument then placed in the casing P, and the wires d, d^1 connected by means of the electric cable with a source of supply of electrical energy. In use the instrument is lowered in the borehole to the position required to be surveyed. A sufficiently strong current of electricity is then passed through the resistance frame or spiral wire J for a sufficient length of time to melt or liquefy the mass of paraffin wax or other material in the tube A. The current is then cut off, whereupon the compass L assumes its true magnetic north and south positions. The wax is then allowed to cool and re-solidify, after which the instrument is withdrawn from the borehole.

The direction of dip may then be ascertained by observing the declination of the silver mirror M from the horizontal with regard to the direction of the compass L.

Since the above descriptions were written, the design of the compass attachment as illustrated by Fig. 13 has been still further modified and improved. The inner ring and band O, supporting the vertical needle K, has been replaced by a hemispherical cup in which the vertical needle carrying the compass is fixed as in the sketch.

Paraffin wax is poured into the tube until it reaches about half-way up the outer side of the hemispherical cups, and a small quantity of paraffin wax, just sufficient to securely grip the base of the compass attachment, is placed inside the cup.

This arrangement effectually separates the compass needle from the main portion of the paraffin wax, and prevents any possible distortion of the readings from interference with the true balance and freedom of the needle during the period in which the wax is in a molten state.

An iron headgear stands over the mouth of the borehole to be surveyed, and the geared drum carrying the electric cable stands at a convenient distance to the rear of this. The drum can be actuated by either hand-power or mechanical methods. In this case a little 5-HP. steam engine is employed.

In the headgear is a measuring wheel of extreme accuracy, a vital point where there are known obstructions at various points in the hole.

The cable is ½-in. in diam. and contains two highly insulated conductors. It is designed to support its own weight and that of the instrument in a waterless hole of 5,000 ft. depth if necessary, though it is unlikely that it would be required to act at this depth.

One end of the cable is attached to the head above described, and the other is connected in the interior of the drum to two concentric contact rings, which are placed in communication, by means of carbon brushes, with the galvanometer in the continuously recording instrument, or the source of electrical energy in the intermittently recording instrument.

The galvanometer itself is of special design, and is calibrated to read, at a pressure of about 4 volts, the make-and-break records of the continuous clinometer, and it is also designed to record the rise in temperature indicated by an electrical thermometer.

A small dynamo, run by the steam plant, is used to supply the necessary current for melting the paraffin wax in the compass and clinometer instrument.

The compass and clinometer readings are made by the aid of a protractor of simple design, in which the instrument can be clamped in reverse positions, thus nullifying any errors due to lack of adjustment.

BOREHOLE SURVEYS.—Figs. 18 and 19 give plans and sections which illustrate the results obtained from surveys of two boreholes sunk on the property of the Turf Mines, Limited, near Johann[illegible]e surveys were entirely made with the above-described instruments.

The following extract from the report which accompanied these drawings will sufficiently explain the extreme value—and, indeed, the absolute necessity—of having an accurate survey of any borehole which has been sunk to prove the depth of a mineral deposit.

The East Borehole.—This hole is situated 1,100 ft. from the north boundary in the eastern portion of the property.

The South Reef was struck at a depth of 4,802 ft., this being at the time assured to be its position vertically below the mouth of the borehole. A survey of this hole has since been made and the results obtained are shown in Fig. 18.

The horizontal plan shows that the hole on deviating from its vertical position took a northwesterly course with a tendency to continually turn more directly towards the north against the strata.

The greatest depth to which it was possible to lower the instruments was 4,000 ft. along the course of the hole; at this point the readings showed the borehole to be in a direction of 19° west from the true north at an angle of 60° from the vertical. For the purposes of calculation this direction was continued from the last reading to the recorded depth of the reef at 4,802 ft. The reef is thus shown to be struck at a point 2,185 ft. away from the vertical line passing through the mouth of the borehole, in direction north 28° west from the point at which the borehole was commenced. The actual vertical depth of the reef where struck in the borehole was 3,910 ft. below the surface.

As the result of numerous observations in the vicinity of the property, the average dip of the country is taken as 26° from the horizontal, and the strike is due east and west. The estimated depth of the reef vertically below the mouth of the borehole is thus calculated as 4,845 ft. below the surface, or 43 ft. deeper than the figure previously given.

This almost negligible difference in the estimated depths of the reef in this instance is due to a fact, which is gradually gaining corroboration in each successive borehole survey made, that the deep borings on these fields have a tendency to deflect from their original vertical course into a direction against the strata, thereby recording a section of country approximately to that which would have been observed had the borehole retained a vertical position. It is most fortunate that this remarkable automatic correction occurs in the manner above stated, for it is almost superfluous to point out that had it been the tendency of the holes in boring through Witwatersrand strata to take a direction with the dip of the strata instead of against it, then the reefs of the Turf mines property would not have been intersected to this day.

The West Borehole.—This hole is situated 900 ft. from the northern boundary of the property and 1,800 ft. to the west of the mouth of the east borehole.

The results of the final survey are shown in Fig. 19. The point of intersection of the South Reef which was previously recorded as being struck at 4,742 ft. in depth vertically below the mouth of the borehole is now shown as being in a position 2,175 ft. distant from the vertical line passing through the mouth of the borehole, in a direction north 15¼° west from this point.

The reef where struck is 3,745 ft. vertically below the surface, and the depth of the reef vertically below the mouth of the borehole is thus calculated, in accordance with the data enumerated above, as 4,765 ft., or 23 ft. lower than the previously recorded depth.

The similarity of the courses taken by these two boreholes gives further evidence of the predominant tendency of the boring rods to turn against the strata.

A recent survey of the Rand Victoria No. 2 borehole made by these instruments is also worthy of record.

This was a particularly interesting survey, in that the hole had assumed a spiral course in detail, in addition to its general increasing deflection from the vertical as the depth increased.

THE LIGHTING OF MILL BUILDINGS.*

By C. A. Raymond.†

I shall not attempt in this paper, to bring out anything new, but to briefly touch on some points of interest to all who are in any way connected with building work. However, since the lighting of a building is of first importance in its efficiency the time will not be lost, especially as many of you are in a position to give practical experiences of great value.

It would seem that only very recently has the lighting of mill buildings occupied the attention of designers in this country to any extent, but rapid strides are being made in the direction of better diffusion. Also the area of glass in most buildings has been largely increasing, in some instances to excess. The area of glass may be limited by the following points: (1) In mill buildings where double glazing is too expensive the heating is naturally rendered more difficult by an increase of glass surface. (2) An excess of clear glass in the windows or skylights, when exposed to direct sunlight, is apt to make the building excessively warm, unless covered during the warm season by a coating of white lead or similar preparation to make the glass translucent. (3) The expense of replacing broken glass in some classes of shops may be considerable, though this may be obviated by proper protection.

The location of a building with respect to the points of the compass, largely affects the quality of the lighting. It is a well-known fact, especially among photographers, that the north light is clear and even at all times of day and year. This can not be said of any other direction, although the light from other points may be more intense much of the time. It is, however, not so important to get a large quantity of light as to get what you may have, well diffused. These facts have developed the saw-tooth roof, a European type, which is now being used in some very good buildings in this country, notably in the main shop of the American Bridge Company at Ambridge. There are several strong objections to it but much also, to be said for it. It is not difficult to design a building so that this roof may be used no matter how the land may lie with reference to the points of the compass, the worst case being when the designer is compelled to run his building toward the quarter points. In localities where much snow falls this type of roof should be avoided, but where snows are infrequent and not usually deep, as in our own latitude, it offers as a rule, a very satisfactory method of lighting though some means must often be provided for warming the gutters to dispose of the snow and ice rapidly. Gutters should be specially large or leakage is apt to occur.

As far as possible roof lights, to be most efficient should be placed normal to the direction of the desired source of light. This is illustrated by the use of saw-tooth which is inclined at an angle of about 20° to the vertical ribbed glass, has done much to improve the quality of light in mill buildings. Ribbed glass acts as a cheap substitute for prismatic glass, owing to its great diffusive qualities and low cost, extensively used in both skylights and windows. It is no doubt most effective for windows when the ribs run horizontally, but shop men who have worked by it without shades find it troublesome to the eyes when exposed to direct sunlight, on account of the glare. This difficulty may be effectively removed by shades, but these are ordinarily considered too expensive. With the use of this glass the central part of the room gains a large part of that light which in the case of ordinary glass falls on the floor near the windows.

Translucent fabric is a fairly low-priced, and, I understand, otherwise good substitute for glass. It is translucent and not transparent it is good for skylights. It is used in at least one local building.

In order to aid in the diffusion of light the interior may be painted white. The American Bridge Co.'s Template, Blacksmith and Machine shops at Toledo, have the brick curtain walls covered with ordinary whitewash.

In the Template shop, where there is a minimum of dirt the wall have remained in fairly good condition for more than two years.

Theoretically the windows of shops are readily kept clean, but practically they may or may not be so cared for, and in cases where smoke and dirt are excessive this becomes a decided factor in the lighting problem.

Condensation is a point to be reckoned with in skylights, but is usually cared for by means of gutters placed at intervals underneath the glass. Many kinds of roofing, also, are troublesome on this account.

*A paper read before the Toledo Society of Engineers.
†Assistant Engineer, Toledo Plant, American Bridge Co.

A NOVEL SNOW COMPRESSING MACHINE.

The problem of removing snow from city streets has been attacked by many inventors, nearly all of whom have attempted to melt the snow. It has always appeared to us that the latent heat of liquefaction was an insurmountable obstacle to the commercial success of any device of this type.

We illustrate here a machine for dealing with snow which operates on an entirely different plan. The inventor saw that it is not the weight of snow so much as its bulk that makes its removal from city streets expensive, and, instead of trying to melt the snow, he made a machine to reduce it to solid blocks.

It consists essentially of a receiving hopper, a screw for compressing the snow and a compression chamber. So long as snow is fed into the hopper and the screw is revolved, the machine will turn out blocks of snow compressed to a density almost as great as the density of solid ice. The experimental machine shown in Fig. 1 is mounted on skids, but it is obviously an easy matter to make a self-propelling machine mounted on wheels; and, in fact, patents for such a machine have been granted. One of the patents shows a rotary sweeper delivering the snow into an elevator which empties into the snow compressor. This patent is No. 684,051, granted Oct. 8, 1901, to F. W. and H. S. Farquhar. Another patent, of the same date, No. 684,052, was issued to H. S. Farquhar, of Washington, D. C.

There is one feature of the machine that is not embodied in the patent papers and that is the idler or middle screw which has been found necessary to keep the compressor screw clean of snow and prevent choking.

When the machine is first started it is necessary to block the exit temporarily, for otherwise the snow pours out uncompressed; but, once the first block is formed, the machine operates continuously. Retarding devices, on springs, keep a uniform resistance against the forward movement of the block. A very slight groove is sheared in the blocks by these retarders. The compressed mass is broken into blocks by its forward movement, the mass breaking off at the end of the compression chamber just after the end strikes the incline.

Mr. Farquhar states that the blocks are of the same density regardless of the original quality of

the snow, and that he has not found any kind of snow from the lightest to the wettest slush and cracked ice, that this machine will not handle and compress. A brief summary of the types of machine built and tried by Mr. Farquhar is as follows:

(1) Compression between rolls: Failed, material being neither malleable nor ductile, it could not be drawn through.

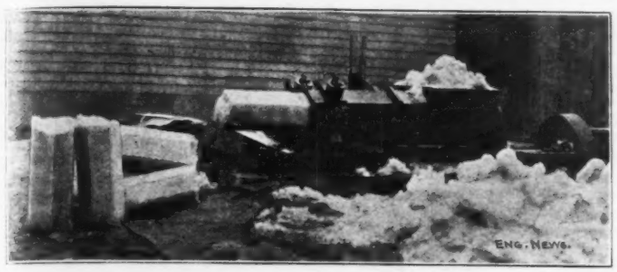


Fig. 1. A Novel Snow Compressing Machine.

(2) Compression between one roll and stationary plate: Failed, for same reason as Case 1.

(3) Compression by forcing between converging surfaces: Failed, material packed or arched to such an extent that no reasonable pressure could force it through.

(4) Compression in present type of machine except using a piston instead of screws: Too slow, and also block stuck to piston to such an extent that special means had to be provided to prevent blocks pulling back with piston.

(5) Compression in present type of machine without idler for cleaning compression screws: Worked fairly well, but frequently choked.

(6) Compression by present machine: Results as previously stated.

Mr. Wm. B. Upton, M. Am. Soc. M. E., has examined and reported upon this machine for Mr. Farquhar, and we append his report:

After a thorough examination of your "Snow Compressor," said examination having been made on Mar. 3, 1905, I beg to report as follows:

The machine exhibited consisted of two compression chambers, in which revolved two compressor screws of 6 ins. diameter and 2 ins. pitch. These screws revolved at 60 revolutions per minute.

The capacity of the above machine under the conditions named was 4 cu. ft. of snow per minute.

The compression on each block was about 600 lbs., or an average pressure of about 20 lbs. per sq. in.

From the above figures I find that the power consumed for actual compression in the above machine was 12,000 ft.-lbs., or about ⅓ HP.

The compressed blocks from the above machine weighed 55 lbs. per cu. ft. Solid ice weighs 57½ lbs. per cu. ft. Therefore, the compressed blocks weighed within 2¾% of solid ice. In this particular I might add that of course the blocks could be compressed harder by applying more pressure to the compression regulating device, but I consider that sufficient pressure was used for the commercial purposes of the machine, as the blocks would remain intact and could readily be handled with a pair of ice tongs.

Figures relating to snow are extremely rare, but from those I have at hand I conclude that your machine on absolutely dry, fresh snow, would be capable of obtaining a reduction of as high as 92% in bulk. This class of snow, however, is rarely found on city streets, but I am of the opinion that you may expect an average reduction of at least 75%, probably 80%, and possibly as high as 85%.

The expense of hauling, in cleaning the streets of snow by present methods, should be reduced in almost direct proportion to the amount of compression you obtain, as the capacity of wagons and carts used for the purpose is at present not limited by the weight the horses can pull but by the bulk of snow that can be loaded on the vehicles.

If we assume that it costs 10 cts. per cu. yd. for shoveling the snow from the pavement, and 25 cts. per cu. yd. for hauling it to the dump, 71% would be the proportion of cost for hauling. (These I understand are approximately the relative costs in New York.) If you obtain an average of 80% reduction by compression, you will save 80% of the above 25 cts., or 20 cts. per cu. yd., making your total expense for removal about 15 cts. per cu. yd. A reduction of 57% of the total cost. The cost of removal in other cities than New York is much higher per cubic yard.

Your machine as constructed is extremely simple, as the only moving parts pertaining to the compressor itself are the compressing screws, and I see little likelihood of its getting out of repair or breaking. Its cost of maintenance should be very low, and it should be capable of efficient and continuous operation.

In conclusion, I am of the opinion that the commercial machines you contemplate building, with their more refined details of machine work and material, will certainly operate as successfully, and probably with more efficiency, than the smaller one you have exhibited to me.

THE USE OF PORTABLE GRAVITY TRAMWAYS AND SMALL CARS IN STOPES IN SOUTH AFRICAN MINES.*

In stopes of small inclination the use of some form of conveyor has become the general practice. The Aerial Tramways and Jigging Conveyors described in last year's report are in use on many mines.

Another form of conveyor has been found very successful at the Lancaster G. M. Co. It is the invention of Mr. J. Faull, the manager, and takes the form of a double line of tramways on which a pair of skips are operated by gravity under the control of a brake. The two skips are joined by a wire rope which passes round the brake drum at the head of the stope. The full skip pulls up the empty one. The skips are self dumping at the lower bin, this being effected by a door at the lower end of each skip which opens automatically when the skip lands on a buffer baulk at the ore bin.

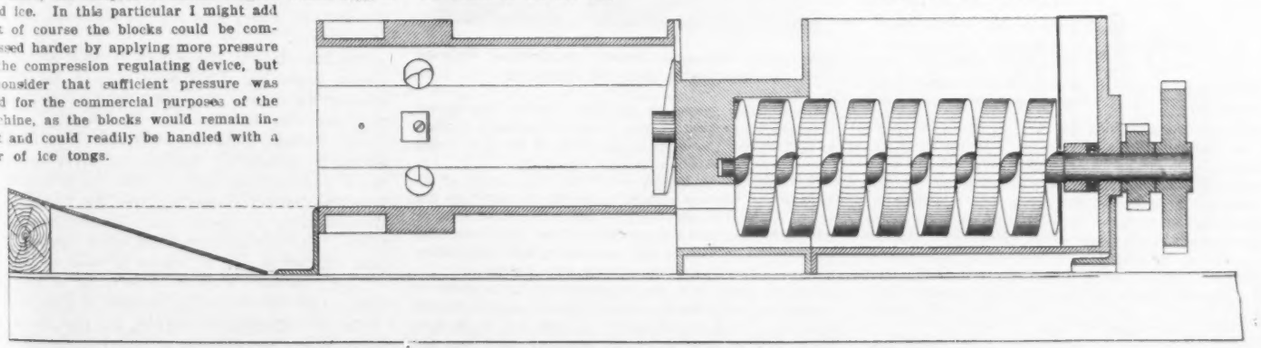


FIG. 2. LONGITUDINAL SECTION OF A NOVEL SNOW COMPRESSING MACHINE.

I understand that you contemplate making your full-sized, commercial machines with 18-in. diameter screws with 6-in. pitch. This should give you a capacity 27 times greater than the present one, or 4 cu. yds. per minute. This should be ample for any single machine. Such a machine would require 9 HP. for the actual compression, and allowing liberally for friction of the machine, etc., a 15-HP. engine would certainly be enough. This engine could be either steam or gasoline.

It is impossible to estimate what advantage would accrue by utilizing the heat from the exhaust of the engine, but it would certainly be of some value, and as it would otherwise go to waste, I would utilize it and gain what advantage there may be.

The claim to novelty consists in the portable nature of the apparatus, sections of parallel rails being fastened to the required gage by light sleepers, in suitable lengths, which can be connected and disconnected readily, and which also can be folded over on to one another for the purpose of removal or storage. Besides the facility of handling which the hinging affords for folding purposes, it also allows the rail track to accommodate itself to the uneven contour of a stope floor, and in practice it has been found that this flexible track is admirably adapted for the purpose for which it is designed.

It has been found desirable to construct the track in sections of different lengths, the shorter sections of 3 ft. being found to follow sharp undulations of the floor more closely than the 9-ft. sections, which are suitable for stretches that are less uneven.

In the narrow stope between the second and third levels of the Botha Mine about 70 ft. of parallel double tracks are laid, made of 3-ft. sections of 18-in. gage. On these tracks are two skips of 9 cu. ft. capacity each.

In another and wider stope between the sixth and seventh levels similar tram lines are being worked, only in this case the tracks are of 2-ft. gage, and the sections in lengths of 9 and 3 ft., whilst the skips are of 16 cu. ft. capacity. The number of boys engaged in serving these two skips, which convey a ton of ore from the front face to the ore shoot, a distance of some 70 to 80 ft., every two or three minutes, is eight, viz., six at the loading station, one operating the brake, and one clearing the discharge. The installation of this folding track allows 10 shovellers to be dispensed with, besides more rapidly performing the work.

Regarding the portability of the tram lines, 4 ft. of single track was folded up and transported in 4 mins., and relaid in 6 mins. These times need to be doubled to obtain the rate for rigging and unrigging the double track. It has been recently definitely proposed to use belt conveyors, in 600-ft. lengths, to handle the ore on the main incline (complementary to the main vertical shafts) of the deep level mines of the eastern section of the Witwatersrand. The inclination of the reef is not expected to be greater than 20°, while it may be as flat as 8°, and it is felt that some method of continuous mechanical transport will prove more economical than ordinary methods of skip winding.

*Abstracted from the 1904 Annual Report of the Government Mining Engineer, Transvaal Mines Dept.

A TEST OF A SMALL-SIZED GAS PRODUCER AND GAS ENGINE.

We have been favored by Mr. Chas. E. Fowler, Superintendent of the Poughkeepsie, N. Y., Water Works, with a report of a recent test of a gas producer and gas engine plant at the Poughkeepsie pumping station. We reprint it substantially in full as follows:

The gas producer is a 50 HP. suction producer, made by R. D. Wood & Co., of Philadelphia, Pa., and the gas engine is a 35 HP. vertical, two-cylinder engine, built by the Westinghouse Machine Co., of Pittsburg, Pa. The centrifugal pump is a 10-in. volute with enclosed impeller, made by Henry R. Worthington, of New York, and is driven by a 12-in. horizontal belt from the engine pulley. The distance between centers of pulleys is 28 ft. The velocity of the impeller is 450 revolutions per minute; the diameter of impeller is 28 ins.

The quantity pumped was determined by a water meter measuring a fractional part of the total through a by-pass in the delivery pipe. The ratio of the quantity recorded by the meter to the total was ascertained by discharging the total into two watertight basins, having a combined area of 28,853 sq. ft., and noting the rise therein by hook gages reading by verniers to thousandths of a foot, also reading the meter simultaneously.

The pressure gage used on the discharge pipe was tested by a water column 25 ft. high. It was found to be in error 1.36 ft. in excess.

The combined efficiency of belt and pump was determined by ascertaining the brake HP. of the engine and dividing the power due to volume pumped and total lift by it. The separate efficiency of belt and pump is estimated.

The result of the brake test was as follows:

Radial length of lever ..... 10 ft.
Net weight on scale, with engine at full load.... 68 lbs.
Number of revolutions per minute.. 300

$$\frac{10 \times 2 \times 3.1416 \times 68 \times 300}{33{,}000} = 38.8 \text{ HP.}$$

The test of the entire plant was made on May 18 and 19, 1905, and the brake test of the engine was made on

June 13, 1905. In both cases the engine was operated at full power.

The fuel used was anthracite pea coal of the quality ordinarily used at this pumping station.

Duration of test, hours	24
Reading of fractional meter at start, cu. ft.	10,555
Reading of fractional meter at close, cu. ft.	12,128
Cubic feet of water registered by meter	1,573
Ratio of meter registered to total quantity	1 to 272
Total cubic feet pumped	427,856
Total number of gallons pumped	3,200,362
Number of gallons pumped per minute	2,222,46
Number of lbs. of water pumped per min.	18,521
Register of pressure gage on pump, lbs.	10
Height of water due to reading of gage, feet.	23.06
Deduct error of gage, feet	1.36
Correct height above gage, feet	21.70
Average height of center of gage above surface of water in pumping well, feet	14.53
Head required to deliver water through foot valve and suction pipe, feet	1.6
Head required by one 90° bend, feet	.9
Total height below gage, feet	17.03
Total lift of pump, feet	38.53
Net horse-power required $\frac{18,521 \times 38.53}{33,000}$ =	21.62
Combined efficiency of pump and belt, determined from test of engine	.557
Estimated efficiency of centrifugal pump	.607
Estimated loss by belt	.05
Power developed at shaft of engine, HP.	38.8
Total pounds of coal consumed	1,151
Pounds of coal consumed per hour	47.95
Pounds of coal consumed per HP. hour	1.23

The duty of the entire plant is:

$\frac{3,200,362 \times 8.33 \times 38.53}{11.51}$ = 89,211,691 foot pounds per 100 pounds of coal.

THE MARKET ST. ELEVATED RAILWAY, west of the Schuylkill River, Philadelphia, was put under construction on July 17.

THE PHILADELPHIA GARBAGE CONTRACT FOR 1906 has been awarded to The Penn Reduction Co. for $399,575, as a result of the bids received on July 13. This is $44,425 less than the bid of the Urban Wastes Disposal Co., of New York, to whom the contract was about to be awarded, under bids received on May 4, when Mayor Weaver ordered a readvertisement; and it is $160,425 less than the price being paid the American Sanitary Product Co. for garbage collection and disposal this year. No definite information regarding the parties behind the successful bidders nor the process to be used had been made public at the time of the award. The company was then organized under the laws of Delaware, with Albert El Peterson, a lawyer, and Thos. S. Louderbach, a notary, both of 14 South Broad St., as president and secretary. It is understood that a new reduction process is proposed.

THE 16,000-TON BATTLESHIP "KANSAS" will be launched at the yard of the New York Ship Building Company, at Camden, N. J., Aug. 12.

REINFORCED CONCRETE DOME OF CENTRAL RAILWAY STATION, ANTWERP, BELGIUM.

The accompanying view of the dome of the central railway station at Antwerp, Belgium, illustrates in an interesting manner the flexibility of reinforced concrete as a structural material. We are indebted to a paper read at the recent meeting of the Institution of Mechanical Engineers of Great Britain by Mr. E. Noaillon, of Chênée, near Liége, Belgium, for the illustration and following description:

This dome springs from the level of the roofs of the mass of buildings of the station at a height of 130 ft. above ground level and rises another 130 ft. to the spire. It is entirely constructed of ferro-concrete, by the firm of Vasanne of Brussels. The work was originally intended to be built in stone, but it was discovered that the foundations would not carry such a weight, and therefore ferro-concrete was preferred, as it could be built hollow. However, it was necessary to follow minutely the form of the original design, which, rationally conceived for a massive material like stone, often presented serious difficulties of execution in ferro-concrete.

The dome comprises four large glass lights placed upon the sides of a square, and upon these rests the actual dome which in its turn supports a campanile. Each glass light is in the form of a gallery with seven arcades surrounded by a demi-arch of 32.8 ft. radius. The arches are framed by an archivault of 11.5 ft. height, which receives at its periphery the haunches of the dome.

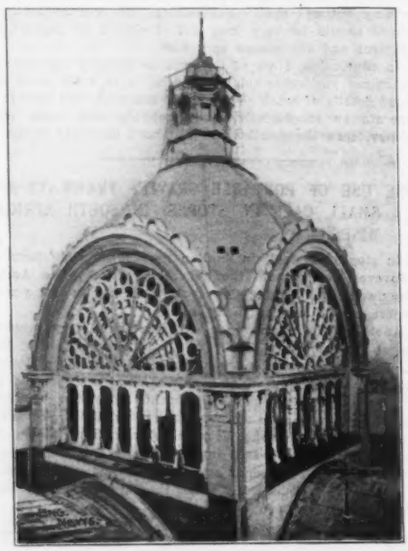
The entire structure, which is 1,800 tons in weight, rests entirely upon the columns at the angles of the glass lights, for it was only at these points that a solid support could be obtained. These columns are Y-shaped in the cross-section, which has an area of 10.7 sq. ft., and they are subdivided at the height of the centers of the arches into three beams.

The tail of the Y is extended in the diagonal plane in the form of a thrust block rising obliquely between the two shells of the dome. Each of the limbs of the Y forms the abutment of the beams in the arch, 8.2 ft. high, situated in the archivault. In the horizontal plane passing through the tops of the archivaults is placed a beam in the form of a flat ring 4.92 ft. wide, which is supported at eight equidistant points, which are the four tops of the archivaults and the four ends of the thrust blocks.

This beam serves two purposes—it balances the horizontal reactions due to the obliquity of the thrust blocks, and resists the tensile stress created by the joists of the dome. At the top of each beam of the archivault are hooked two tie-rods which go down in the two midribs of the arches and extend into the two central columns of the gallery of arcades, and support in its place a horizontal beam hidden in the entablature of the gallery, and supporting all the lights; it is obvious, therefore, that all the weight of the latter is supported by the columns.

The dome consists of two superposed shells at a distance apart varying from 3.28 ft. to 6.56 ft. The internal shell which forms the ceiling of the entrance hall is completely decorated with sunk molded panels; some are round and others square, and they diminish in depth and size progressively from the springing to the summit. They leave only flat bands on the inside of the shell, and these follow a series of meridians and parallels. A part of these flat bands are formed by a skeleton of joists and trimmers which are supported on the annular beam, and they carry the whole weight of the dome. This skeleton was first erected, and served to support the cores which formed the molds for the panels, and then the latter were filled in with concrete.

The external shell has a uniform thickness of 3.15 ins., and it is relieved by six molded ribs following meridian lines. It is supported upon the internal shell by small



Reinforced Concrete Dome for Central Railway Station at Antwerp, Belgium.

distance pieces normal to the two surfaces; this method of support has been chosen to allow as much freedom as possible for the unequal expansion of the shell owing to the rays of the sun striking it obliquely.

The most interesting feature of the construction of the dome of the Antwerp station is that all the moldings and all the sculptures, which are so numerous and of so many different forms, have been executed by direct molding, and not, as is usually the case, by rough applications which are trued up afterwards by gage boards.

It would never have been possible to make in wood the numberless molds which would have been needed for the latter process particularly as the work had to be done upon surfaces bent often in two directions like the panels of the dome.

M. Vasanne has invented a very ingenious system of molding. He begins by executing in plaster the model of the sculptures which are to be reproduced in the concrete. He then spreads upon this negative mold a layer of 1.2 to 2 ins. in thickness of a paste made of sawdust and magnesium oxychloride. This paste hardens rapidly and gives him the desired mold, which is light, strong, and can be worked like wood; the same negative mold can be used several times.

The manufacture of the glass lights was specially difficult because of the great richness of the ornamentation and of the exactitude with which the molds had to be made to obtain a perfect fitting of the different moldings. The part of the glass lights which forms a gallery was filled with concrete at one operation in a mold built up in position on the site. With regard to the part in the form of a half rose, a complete mold was arranged upon a perfectly level platform. This mold showed, therefore, in hollow all one face of the half rose.

The concrete was molded to a thickness of 2 ins., and then the molded part was cut into portions specially marked. Then the molding, followed by the same division into parts, was repeated to obtain the opposite face. In this way two corresponding portions placed back to back formed one hollow structure representing one element of the glass light. The parts were then used to build up the light, just as stones would have been employed, but care was taken to pass bars of iron into the hollow part, and then to pour in concrete, so as to obtain a monolithic structure which possesses great rigidity.

FLOODS IN THE SOUTHWEST, 1904-5.

During September and October, 1904, and the first four months of 1905, heavy rainfalls occurred throughout the southwestern part of the United States, doing much damage as far north as Kansas.* In New Mexico the flood of 1904 necessitated the rebuilding of 6½ miles of Santa Fe track, from Watrous to Shoemaker, at a cost of $40,000 a mile; and at and near Carlsbad, N. M., irrigation works and bridges were damaged (see article on "Failures of the Lake Avalon Dam," Eng. News, July 6, 1905). At many other points dams and bridges have been carried away.

A table of monthly rainfalls for January to April, inclusive, 1905, shows very high precipitation for 23 stations in the Gila River drainage area, in Arizona and New Mexico. The highest total shown for these four months was 23.90 ins. at Jerome, Ariz., as compared with a mean of 6.21 ins. for previous years. The monthly rainfalls and means at this station were as follows: January, 5.10 and 1.44 ins.; February, 7.80 and 2.35; March, 7.30 and 1.35; April, 3.70 and 1.07 ins. At a number of stations the 1905 record was five to six times the mean for the corresponding four months, while at Lordsburg, N. M., the figures were 9.43 and 1.38 ins., respectively, or more than 7 to 1.

Had the dam on the Salt River, at Roosevelt, been completed, Mr. Murphy states, the reservoir to be formed by it would have been more than filled by May. The floods on this river delayed the work on the dam. Contractors could not get supplies for their horses and mules, and thus were forced to turn them into the mountains to forage.

The Colorado River, below the mouth of the Gila, has been in flood and has discharged large volumes of water into the Imperial Valley, in California. Part of this valley is below sea level and it was feared that the Colorado would break completely through the low ridge which separates it from the valley and fill the latter to the level of the river.

The Rio Grande River was in flood some three weeks, beginning about May 18, and doing much damage to crops. The old adobe Mexican town of Tome was destroyed by this flood.

The Kansas floods of 1903 and 1904 have resulted in legislation authorizing river protective work and also in some actual construction. A drainage district extending from the mouth of the Kansas River to a point above Argentine has been formed and plans have been made for works to pass 160,000 sec.-ft. of water without overflow.

The floods have washed away many of the gages and a few cables at the stream gaging stations of the U. S. Geological Survey, but the few breaks made in the records are of short duration.

Benefits as well as damages have resulted from the floods. Some lands have been enriched by silt deposits, others have had alkali washed out, and all have been well soaked. As a result, Mr. Murphy states that immense tracts that are usually barren are now covered with grasses and flowers.

*These and similar occurrences throughout the country have been reviewed by Mr. E. C. Murphy, Inspector in Charge of Stream Gaging Stations for the Hydrographic Branch of the U. S. Geological Survey, and will be published later on as Water Supply and Irrigation Paper No. 147, "Destructive Floods of 1904." We are indebted to Mr. Murphy for manuscript notes from which the information here given has been taken.

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The article on "Dirt as a Source of Disease," reprinted in another column, shows the real and exposes some of the imaginary dangers from dust and dirt. To the many good suggestions of the article we should like to add that further progress in controlling communicable diseases depends largely upon bringing the general public to a realization of the fundamental principle of modern sanitary science: that individuals suffering from communicable diseases are the primary sources of infection. The ideal of every organized community, no matter how small or how large, should be to discover and put under observation and control every case of communicable disease at its very inception. Such discovery necessitates immediate reports of all cases of communicable disease to the health authorities, and such control involves more or less complete isolation of the patient and thorough disinfection of the germ-laden discharges from the patient, of his clothing and bed linen, and finally of the room or perhaps the whole house which he occupied. The more thoroughly all this is done the less dangerous will be the dirt and the air of household, building and street; and more important still, the safer will be the water and milk and other drinks and foods of the human race.

A story is told of a certain famous inventor who is fortunate enough to be able to employ a large staff of engineers and mathematicians to aid him in the solution of knotty problems. Some time ago the inventor desired to find the cubic capacity of a certain vessel of unsymmetrical proportions, and asked his mathematicians to solve the problem. As the story goes, the mathematicians spent weeks of time, filled whole books with their calculations and finally presented what they said was a close approximation to the true result. Thereupon the famous inventor placed the vessel on a platform scale, filled it to the brim with water, obtained its weight when full and when empty, and in a few minutes he had a result as good as the mathematicians—for that particular vessel.

The story is good as far as it goes; but such short-cut methods of avoiding mensuration problems are not always possible. Further, while such stories greatly impress the non-technical reader, the engineer is aware that the mathematical solution—when a mathematical solution is possible—may be made available for vessels or bodies of other sizes or shapes than the particular one under investigation, and may afford useful information as to the influence of alterations in size or shape upon the capacity.

We publish in this issue an example of the application of mathematics to a difficult problem in mensuration—the determination of the contents of conical piles of material enclosed by walls at the base. The problem is one which is likely to be presented to almost any engineer in general practice on account of the rapidly increasing use of conveying apparatus for storing coal, ore and other materials in heaps upon the ground. The paper which we publish gives merely the results obtained by the authors. The actual operations necessary to develop the diagrams and tables, we are informed, involved an immense amount of labor, and it was deemed worth while to make the results of this labor generally available to the profession.

In our issue of April 20, in discussing the recommendation of Messrs. Burr, Parsons and Wallace for a sea level canal at Panama, we raised the question as to how the diversion of the rivers along the canal line was to be provided for, and said:

> A sea-level canal will be for a great part of its length far below the level of the adjacent country, and will have to be protected from the floods of adjacent streams, which would otherwise be continually filling it with silt. The floods from the upper Chagres will be taken care of by the storage reservoir created by a dam at Gamboa; but the watershed of the Chagres between Gamboa and Bohio has an area of 250 square miles, and the flood outflow from this whole area must be kept out of the canal prism, if a sea-level plan is adopted. This will necessitate, it would seem, a large expenditure for the construction of river diversion channels between Gamboa and Bohio; and it would be interesting to know what provision has been made for these in the comparative estimates.

On another page of this issue we have the pleasure of presenting a paper by a distinguished officer of the Corps of Engineers, U. S. A., in which the question of the disposition of floods and silt from the streams in the Chagres valley is ably discussed. Major C. E. Gillette, the author of the paper, has had large experience in river control and lock and dam construction, and he has made a close personal study of the conditions of the Isthmus, having been detailed to accompany the Commission of 1904 to Panama and assist it in the organization of its force.

It is within our knowledge that Major Gillette went to Panama with preconceived opinions in favor of a sea-level canal at a time when nothing had been heard of any plan being feasible at Panama save the lock canal recommended by the Commission of 1900. It is, therefore, extremely interesting to note that actual study of conditions on the ground led him to reverse his opinion and to conclude that a canal with locks is the best solution of the Panama problem.

The plan which Major Gillette proposes for the canal is quite similar to that favored by the late Geo. S. Morison; but instead of building a great dam at Bohio, as Mr. Morison planned, Major Gillette would build a dam at Gatun, ten miles nearer the Atlantic, and reduce by that much the length of canal necessary to excavate. He would build this dam of the earth and rock taken out of the great divide cut at Culebra, as was suggested by Mr. Morison for the Bohio dam.

At both Bohio and Gatun, the rock is at too great a depth to make it possible to excavate down to it and build an earth or rock dam in the ordinary fashion. Mr. Morison proposed, therefore, to drive sheet piling along the line of the Bohio dam in order to cut off as much flow as possible through the permeable strata beneath the dam; and he maintained that the flow through the lower strata, beneath the bottom of the sheet piling, would not be great enough to be of any importance.

For the dam at Gatun, Major Gillette proposes to follow substantially on the lines laid down by Mr. Morison; but in addition to the line of sheet piling, as a further safeguard against undue percolation of water through the deep strata beneath the dam, Major Gillette proposes to sink piping down to bed rock and force cement grout through it to close such openings as may exist in the sand or gravel strata. This system of forcing grout into permeable underground strata has been used to a considerable extent by Mr. W. R. Kinipple, M. Inst. C. E., in England, by the late Robert L. Harris, M. Am. Soc. C. E., in this country and by other engineers.

Certainly, therefore, Major Gillette's plan for a canal at Panama has excellent precedents back of it; and it will undoubtedly receive the careful attention of the recently appointed Board of Consulting Engineers on the plan of the canal.

The use of the diamond drill and other devices for boring to great depths to locate mineral deposits, and ascertain their extent and character, is destined to become a much more common practice in the future than it has been in the past. This is due: (1) To improvements in boring devices, and consequent lowering of the cost of deep boring; (2) to the exhaustion of surface deposits, and the increased value of deep deposits; (3) to the economy in opening up a mine the extent and value of whose deposits are known in advance; and (4) to improved methods of surveying deep bore holes.

This last factor is by no means unimportant. Bore holes are rarely plumb, except where the strata penetrated are horizontal—and not always then. With inclined strata, and particularly where the hardness of successive strata varies considerably, there is a tendency for the bore hole to deflect from the vertical. This deflection is usually in the direction of the dip of the strata, but it appears, from the article published elsewhere in this issue, that occasionally the bore hole may deflect so as to approach a line more and more nearly perpendicular to the inclined strata. This may possibly be explained by the fact that the drill passes from a thick, hard stratum to a thin, soft stratum, and the slow cutting of the lower part of the hole in the hard stratum permits the edge of the drill that has entered the soft stratum to work ahead faster. A repetition of this condition will in time give the drill hole a remarkable twist from the vertical. Now, it is apparent, that the drill cores would be wholly misleading unless their exact location were known. The proper survey of a bore-hole is, therefore, of entreme importance. Most of our readers are familiar with the old methods of using melted wax, which is allowed to solidify in a glass tube lowered into the hole. But at great depths the water in the bore hole may harden the wax before it has reached the bottom of the hole. Moreover, the method is slow and delays the drilling. This last objection is even more important where an etching fluid is used to etch the glass tube.

In the article by Mr. Hugh F. Marriott, two ingenious electrical devices for bore hole surveying are described. All who are interested in deep drilling will read this article with pleasure and with profit.

RAILWAY MAINTENANCE OF WAY EXPENSES.

The expenditures for maintenance of way and structures represent from 12 to 25% of the total operating expenses of American railways, but there is very little reliable or definite knowledge as to the itemized or detail costs of the various classes of work included under this general heading. In discussing certain needed improvements in railway track and maintenance of way, in our issue of Sept. 8, 1904, we made the statement that "there appears to be very little definite knowledge of the cost of maintenance of way on individual railways." This statement was indorsed by some engineers prominent in this department, and we have since attempted to procure some information that would throw light upon the subject, but with results that are extremely meager and unsatisfactory. Some of the information given and some of the replies to inquiries are given in another column, and the subject is of such importance that it will be worth while to consider its general aspect.

The annual reports of the railway companies give among the operating expenses the annual expenditures for "maintenance of way and structures," and these are sometimes subdivided into rail renewals, tie renewals, ballasting, roadway repairs, etc., Dividing these sums by the number of miles of railway will, of course, give the average expenditures per mile, but this is of very little use, as the number of miles on which the

work was done does not appear, and this varies each year, while the length of line increases year by year. Besides this, there is little or nothing to show what is included in the lump sum of expenditures given in the report. For instance, taking the case of rail renewals, it should be possible to know not only the total expenditure on this work, but also to know what this includes and on what number of miles the rails were relaid. In this way, it would at least be possible to determine that for a term of years the cost of renewing rails averages a certain sum per mile of track renewed. On some railways it is possible to determine this, more or less definitely, by wading through files of detail reports, but this is rarely done, and as a rule the information is not obtainable in any way. That this is the case is clearly shown by the statements quoted in an article in another column. Some engineers are now introducing special methods of accounting for their own information in this direction, independent of the accounts for the general annual reports.

The first step in our attempted investigation of maintenance of way expenses was to examine the annual reports of railway companies, and to endeavor to analyze them so that comparisons might be made and some general averages or conclusions arrived at. But the information thus obtained was of little value, as the figures given are totals for the entire road, and the classifications are very diverse, ranging from 10 to 25 in number. This lack of uniformity and the absence of any information as to the amount or extent of work covered, makes it difficult to compare results for different roads. The matter was then taken up with the engineering and maintenance of way departments of several railways, but with little success, for reasons clearly set forth in the statements above referred to and given in another column. It was admitted in most cases that figures of this kind are not available or obtainable. We, therefore, come back to a consideration of the annual reports, and one of the tables in the article just mentioned has been prepared in this way and shows the cost of rail and tie renewals on a number of railways for one year. These are not strictly comparable, however, since they represent the total expenditures for these purposes divided by the total lengths of the railways and not by the length of the road on which the work was done. Taking the total miles of track (including sidings), the range is from $19 to $143 per mile for rail renewals, and from $66 to $225 per mile for the tie renewals. On 75% of these roads the cost of tie renewals exceeds that of rail renewals, which is one very significant point.

In the mechanical departments, itemized costs are carried out in very minute detail, and the superintendent of motive power or the master mechanic can present figures of the cost of performing individual operations, and the average cost of various operations, such as turning tires, boring out cylinders, etc. It is true that work on the track is less easily recorded in detail, than is work in the shop, but it certainly should be possible to keep accounts in such a manner that a much more definite knowledge of what is meant by maintenance of way expenses can be obtained than is possible under the present system. In the transportation department, also, the accounts are worked out to show the average expenses and earnings per passenger mile and ton mile, the average load per car and per train, the coal consumption per engine and car mile, etc., so that it may be seen how the itemized expenses compare from month to month and from year to year. But in the maintenance of way expenses, no such comparisons can be made. The expenses for rail renewals, for frogs and switches, for repairs to roadway, etc., may be more or less than in the preceding year (or years), but there is nothing to show why this is or what it means. It is unfortunate that maintenance of way is almost invariably combined with maintenance of structures, as the two classes of work are of different characters and by combining them it is made more difficult to analyze or separate the items. The Denver & Rio Grande Ry. is one of the very few lines which keep separate accounts for maintenance of way and maintenance of structures.

In the accompanying table we have prepared an analysis of the maintenance expenses of 16 leading railways. The first column shows the ratio of the expenses for maintenance of way and structures to the total operating expenses, which ranges from 12.1 to 24.8%. The next two columns show the average cost per mile of road for maintenance of way alone, and for maintenance of way and structures combined. The next three columns show the percentage of total "maintenance of way and structures" represented by maintenance of (1) way, (2) bridges and culverts, and (3) buildings and docks. In the last three columns we have analyzed in the same manner the total expenses of "maintenance of way," showing the percentage represented by (1) repairs to roadway and track, (2) rail renewals, and (3) tie renewals. The desirability of keeping the maintenance expenses of "way" and "structures" separate has already been referred to, and we have followed this as carefully as possible, but owing to the lack of uniformity in the classification or distribution of the expenses, the analysis can at best be only an approximation.

One great difficulty which confronts any attempt at accurate and detailed records of maintenance of way expenses, is that the records must originate with the section foremen and work train conductors. However expert and faithful these men may be, they are not (as a class) familiar with methods of accounting, do not understand the importance or significance of the accounts, and, naturally, give this part of their work as little attention as possible. And it must be remembered, also, that this attention is usually given when the men have completed a hard day's work. The attitude of these men, in many cases, is similar to that of the native in India who was employed to tap car wheels to detect cracked or loose tires. On being asked why he did it, he replied: "I do not know, it is some foolishness, but it is so ordered." Every roadmaster has constant experience of the difficulty in getting time books and material lists made up properly and sent in promptly. They are supposed to be entered up daily, but are often left unattended to for a few days, until it is convenient to tackle them, and then the foreman has only memory and guesswork to rely upon. A stream cannot rise higher than its source, and if the records begin with inaccuracy, incompleteness and carelessness they cannot, in their progress through the department, be rendered complete and accurate. Further than this, the roadmaster very often has but little time to examine, check and study the records that come to his office. Some roads, therefore, adopt the plan of giving the roadmaster a clerk to assist in this work. This is a good plan as far as it goes, but care should be taken that the clerk has instruction both in track work and in proper methods of accounting, and it should also be provided that the results arrived at by his analysis of the section accounts, should be carefully examined by the roadmaster and not merely receive his perfunctory approval. It would seem that here is an opportunity to utilize the young technical graduate and to begin his training for railway service by deputing him to act as timekeeper and inspector on different classes of work. Care would of course be necessary to see that he understands the work and the accounting, and also to ensure harmony in the organization, so that he will not be regarded by the foreman as a spy or an interloper.

The same conditions in regard to the keeping of reports by foremen exist to a large extent in the bridge department of railway service. A committee of the American Railway Engineering and Maintenance of Way Association has been considering bridge department records and accounts for two years, and in its report in 1904 stated that 'the number of forms should be as small as possible, including only such as are absolutely necessary to convey to the higher officers such information as is necessary for the proper and economical management of the railway." This applies equally to the track department. In the discussion it was pointed out by more than one speaker that the cost of each job (particularly in bridge work) should be shown, and the cost of work should be reduced to certain units, but that in many cases the work is done and records are kept in such a way as to make it impracticable to determine the unit costs with any degree of reliability. In the committee's report for 1905, the following statement was made in regard to a general labor report or time-book form for the use of the bridge, maintenance of way and other departments:

> It is not good practice to permit a foreman to carry one time book on the work and transfer his record in the evening to another time book which is forwarded at the end of the month to his superior officer. Good practice requires that the foreman should have only one time book and shall carry the same on his person, shall make up his records while on the work before he has time to forget what has actually been done, and shall forward this book without transcribing any part of the record. A daily record of the work performed is what is actually wanted. When this record is made up on the very day of the performance of the work there is no possibility of error. The proposed time book would be handled according to the following system. The foreman (whether in the track, bridge, building or signal department) would make up the time book at the close of the month and forward the same to his superior officer. The book would be examined and checked by the supervisor of track, bridges, buildings, or signals and then forwarded to his superior officer, the division engineer, in whose office the payrolls and report of distribution of expenses are prepared. The time book would be filed in the office of the division engineer, assistant engineer or engineer of maintenance of way and preserved for a reasonable number of years.

Mr. Beahan in his paper on "The Division Engineer in Railway Work," read before the Western Society of Engineers (Engineering News, June 1), has remarked that the civil engineer is now far more generally employed in the maintenance of railways than he was 20 years ago, and that it seems probable that before very long the division engineer will have charge of maintenance of way. The reason for this is that the special value of the

	Ratio of Maint. of Way and Struc. to Operating Expenses.	Maintenance Expenses per Mile. Way.	Maintenance Expenses per Mile. Way and Struc.	Expenses of Maint. of Way and Struc. Way.	Expenses of Maint. of Way and Struc. Bges. and Culv.	Expenses of Maint. of Way and Struc. Bldgs. and Docks.	Expenses of Maint. of Way. Roadway and Track.	Expenses of Maint. of Way. Rail Renewals.	Expenses of Maint. of Way. Tie Renewals.
	%	$	$	%	%	%	%	%	%
Boston & Maine	15	1,276	1,670	76	7	12	74	4	17
Erie	12.14	1,067	1,710	70	9	14	44	11	14
Lehigh Valley	16	1,600	2,195	71	8	14	63	8	25
Del., Lack. & West.	24.8	2,432	4,000	58	14	25	67	10	16
New York Central	18	1,200	1,488	80	5	13	67	10	18
Norfolk & Western	20	1,354	1,616	80	9	10	40	20	15
Chesapeake & Ohio	18	1,097	1,400	78	6	14	65	13	16
C. C. C. & St. L.	17	1,114	1,433	77	8	8	58	6	20
Wabash	20.82	2,000	2,664	72	14	12	73	7	15
Louisville & Nashville	22.70	1,000	1,550	65	11	7	55	10	16
Illinois Central	17	1,010	1,300	78	9	10	76	6	15
Chicago & North Western	20.25	700	967	74	9	10	65	10	19
C. M. & St. P.	16	570	743	77	13	9	70	10	15
A. T. & S. F.	22	826	1,105	75	13	10	65	8	18
Union Pacific	22	850	1,161	73	11	13	62	13	24
Denver & Rio Grande	22	729	900	82	8	7	60	9	14
Maximum	24.8	570	743	82	14	25	74	20	25
Minimum	12.1	2,432	4,000	58	7	7	40	4	14

Table Showing Expenses for Maintenance of Way and Structures on Short Lines of Light Traffic.

	Miles of Road.	Gross Earnings Per Mile.	Operating Expenses. Total.	Operating Expenses. Per Mile.	Maintenance of Way and Struct. Total.	Maintenance of Way and Struct. Per Mile.	Per Cent. of Op. Ex.
Portland & Rum. Falls	64	$8,263	$310,173	$4,846	$119,000	$1,860	38
Somerset	42	3,192	97,868	2,330	33,000	786	33
Buffalo & Sus.	153	5,482	469,442	3,068	111,000	758	24
Birmingham & Atl.	35	1,287	68,024	1,943	24,000	666	35
Darien & West.	31	413	13,276	426	1,000	32	7
Georgia	307	6,530	1,345,957	4,384	229,000	746	17
Macon, Dub. & Sav.	92	1,982	94,595	1,028	23,000	250	24
Galesburg & Gt. E.	14	1,824	12,192	871	1,000	71	8
Missouri S.	30	2,125	54,790	1,826	10,000	333	18
Wabash, Ches. & W.	65	1,504	72,654	1,117	25,000	384	34

engineer lies in the fact that "he can put a dollar where it can earn more than where another man can put that dollar"; in other words, it is a question of administrative investment. The increased employment of engineers in this department was pointed out in our issue of June 1, and one important way in which the engineer in charge of maintenance work can show his efficiency and his value is in improving the system of records and accounts, and enabling itemized costs to be obtained which will be comparable month by month and year by year. Many contractors have methods of accounts by which the cost of work done may be determined very closely, and these methods may be adapted to railway maintenance and repair work, and also to construction work done by the railway company's forces. Although a railway does not require to make a profit out of its maintenance and improvement work, it is important that it should know what the work costs, not only in total but in itemized and unit costs. Without such information there can be no check upon the economy and efficiency of the work and its administration, and this information cannot be obtained without some better system of records and accounts than is now commonly used for the maintenance department.

As a further illustration of the need of better records of railway maintenance expenses, we may take the question: What is the actual cost of moving traffic? This is a question which must have a more thorough and fair answer in the future than it has had in the past. The railways are beset with appeals for reductions of rates and with movements for State and Federal control over rates. Their officers can stand on sure ground when they maintain that rates ought not to be reduced below the cost of the service; but it will devolve upon them to show what is the actual cost of service and by methods which will stand the most searching tests.

As soon as one attempts to ascertain the cost of railway transportation, however, he finds the necessity of separating the expenses which vary directly with the volume of traffic from those which are scarcely affected by it. For example, suppose the question arises what is the cost of moving traffic on a branch line where the traffic moved is only 100,000 tons per annum. On such a road the first cost of construction and the annual cost of maintenance of way will be nearly as great as if the traffic handled were 500,000 tons per annum. Hence the actual cost to the railway company per ton-mile will, so far as these items are concerned, be five times as great on the road of light traffic as on the road of heavier traffic. But where is the railway official on any of our great systems who can show with some fair approach to accuracy what is the actual cost to his company of moving traffic on the branch lines, or who can even show what is the cost per mile of maintenance on these lines or what is the cost on the main line?

LETTERS TO THE EDITOR.

The Relative Advantages of Plain and Patented Rods for Reinforcing Concrete.

Sir: I have been impressed with the quantity of able advertising the owners of patented rods for reinforced concrete have been getting out, and the apparently convincing arguments that they have been using in advancing their patented material, and correspondingly decrying the use of plain round or rectangular sections for steel rods.

After seeing a great deal of reinforced concrete work and after some investigation on my own account, I have come to the conclusion that plain rods will do all that the advocates of special patented rods claim for their shapes, with a material saving of cost to the construction and with the added advantage that plain rods can be bought in the open market without the annoyance of waiting for material to be shipped from a great distance with its attendant freight charges.

Of course the claim is always made that the adhesion of concrete to plain rods is not sufficient. Tests made at Columbia University in 1903 show that the adhesion to ¾-in. square rusted rods at one month was 437 lbs. per sq. in. and at three months 642 lbs. per sq. in., but that clean rods showed only 294 lbs. and 431 lbs. in similar cases, and painted rods only 63 lbs. and 128 lbs., respectively.

The experiments of Mr. Spofford at the Massachusetts Institute of Technology are often cited to show the superiority of patented rods, but these tests were made on sand blasted rods; that is, on rods with a smooth, glassy surface. Such rods are never used in practice and the wonder is that the plain rods showed up as well as they did, about 250 lbs. per sq. in. adhesion, while the patented rods showed about 450 lbs. per sq. in., which we see from the Columbia University tests is equalled by rusted plain rods. The obvious conclusion from the above is that by letting plain rods rust a little as good results can be secured with them as with patented rods, without paying royalties to patentees and promoters.

A rod 1 in. square at 500 lbs. adhesion per sq. in. will develop in 15 ins. its full elastic strength, with a factor of safety of 3 in 24 ins. for a stress of 16,000 lbs. per sq. in. of rod, which is well within the length of rod ordinarily used in reinforced concrete.

A plain rod as ordinarily used, due to the twists and bends it gets in handling, will also develop considerable mechanical bond, the bends acting as shoulders to hold the rods in place. In case of failure either the concrete will crush along shoulder or the rod will be drawn through a hole in the concrete as a wire through a hole in a plate, which would require great force and would develop a stress far greater than the concrete could resist.

Some of the patented rods are made of high carbon steel for which claims of superiority have been made, but high carbon steel after much discussion and experimenting has been rejected for structural shapes as unreliable. Tests also show that high carbon rods give to reinforced beams in which they are imbedded less uniform and reliable results than beams containing plain rods. But if rods of high carbon steel should prove to be reliable there is no reason why plain rods of such steel should not be manufactured.

The first reinforced section of the Rapid Transit Railroad in New York along Lenox Ave. was constructed with patented rods, but experience and tests showed that they could be dispensed with, and now on the Brooklyn extension of the subway (probably the largest reinforced concrete construction work now being built) none but plain rods are used.

The rods used here are mostly 1¼ ins. square, which, due to exposure, are somewhat rusted. The only treatment they get is a rough scraping to get rid of loose scale or dirt which may adhere to them. Such scale is easily removed by a sharp-edged scraper or the edge of a shovel. Therein has the square rod decided advantage over other shapes and patented rods, for in those other cases dirt and scale have to be removed by laborious treatment with a wire brush, if removed at all.

Yours very truly, L. White.

450 St. John Place, Brooklyn, N. Y., July 5, 1905.

The Doubtful Economy of Light Standard Gage Railways.

Sir: Our views as to the lack of real economy and the many inconveniences of narrow gage railways are so completely in accord that I beg that you will allow me to differ with you in the matter of the construction of light standard (4-ft. 8½-in.) gage railways.

Your editorial in your issue of July 20 suggests the possibility of the omission of the following details:

Right-of-way purchase, saving per mile	$1,000	
Fencing, saving per mile	480	
Ballasting, saving per mile	900	
Telegraph equipment	500	
		$2,880
Perhaps local ties at 40 cts. would save per mile	$275	
Relayer rails at $24 per ton would save per mile	588	
		863
Rolling stock at second-hand would save per mile		2,000
		$5,743

If we subtract this total amount which we may possibly save we will still find one railway costing between nine and ten thousand dollars per mile, and only the manager of one of these makeshift, ramshackle roads can realize how the absence of ballast keeps the track always in wind and racks the already partially worn out machinery—until repairs eat up more than its slender profits—and the general contempt of the community drives away passenger traffic.

True, subsidies may be obtained from towns and villages, but this only helps to pay the real cost of a railway—it does not diminish it.

An average railway requires gross earnings to the amount of 20% of its cash cost to have any hope of a moderate profit. It would appear to me, therefore, that even the poorest of railways should not be attempted where the resources of the country served do not offer at least $2,000 gross earning per mile of road per year. In the particular instance given the accident of having part of the grading done reduces it to $1,400 per mile, and it is hardly probable that in the most level countries this cost will prove less so I have not mentioned it as a possible saving.

The importance of knowing what not to do with money is so much greater than the necessity of finding ways of investing it, that I trust you will pardon my insistance in objecting to an estimate of less than $10,000 per mile as advisable for even the very lightest and most cheaply constructed of railways, with the belief that profits can be earned by it. Very truly yours,

Wm. D. Marks.

The Bourse, Philadelphia, Pa., July 21, 1905.

PROTECTING STEEL BY PAPER COVERING AND PAINT.*

By Louis H. Barker.

About eleven years ago experimental investigation was begun with numerous well-known and established iron paint preservatives, in order to ascertain by actual exposure tests the best one to resist the destructive action on steel structures of sulphurous gases in the form of smoke combined with the moisture of steam, and since that time 50 or more paints and combinations have been tried. Among them were many kinds of asphaltum, rubber, graphite, carbon lead and iron paints, and though the results showed varying degrees of resistance, it is remarkable that even with three coats of paint not one was found that did not show rust in less than a year. Of course, it is to be understood that the exposures were made so as to subject the test bars to the severest action possible in order to obtain the quickest results.

In making the first series of tests new steel plates 10 ins. square were used. As, however, the adverse conditions we were trying to overcome related to rusty steel, which is more difficult to preserve than new steel, rusty plates were substituted in all tests thereafter. And to still further endeavor to meet the existing conditions new plates were hung up and exposed to the smoke fumes until they became covered with sulphur scale, the thought being that an oxide scale due to atmospheric exposure might give different results. This scale or rust formation on these new plates apparently varied not only in amount, but also in the time of its formation, supposedly due to different chemical composition. As this might again give some variations in the expermental results, in order that all paints should be on as like footing as possible, angle bars 11 ft. long were made use of, and, as before, hung in the smoke until rusted, then cleaned with wire brushes, each foot of the bar painted with a different paint and again hung up. The results, however, continued to be unsatisfactory.

In examinations of the test bars from time to time it was seen that upon many of them the paint was intact, but with protruding points which upon being pricked were found to be small rust formations pushing up the paint from behind, clearly indicating that it was not the failure of the paints but the rust action on the inner surface that caused the damage. As no rust can form without the presence of moisture, and as all paints are pervious to moisture (as Dr. Dudley's careful investigations of the subject have proved) this led to the conclusion that it would be necessary in some way to tightly seal the surface. Many kinds of materials for doing this were tried, with as many different results, until three years ago it was decided that a cheap paraffine paper answered the purpose best of all and since that time all experimentation has been along that line. The few test bars that have been brought along and exhibited indicate the results. Besides the experimental bars referred to, the paper covering has been tried in a small practical way against smoke action, and after two years and three months exposure an examination of very recent date shows the outer paint, the paper and the first or adhesive coat all intact and in many places where paper was removed for examination the adhesive coat not yet dry and the surface of steel the same as when painted.

With such satisfactory results from this paper process in the smoke tests, it was concluded to make a large scale application and severe test on a large number of eye beams supporting a floor over and within a few feet of salt water and upon which the rust was due not to smoke but to the almost continuous dampness and presence of sewer gases. This was done over a year ago and up to this time indication of damage of no kind is apparent.

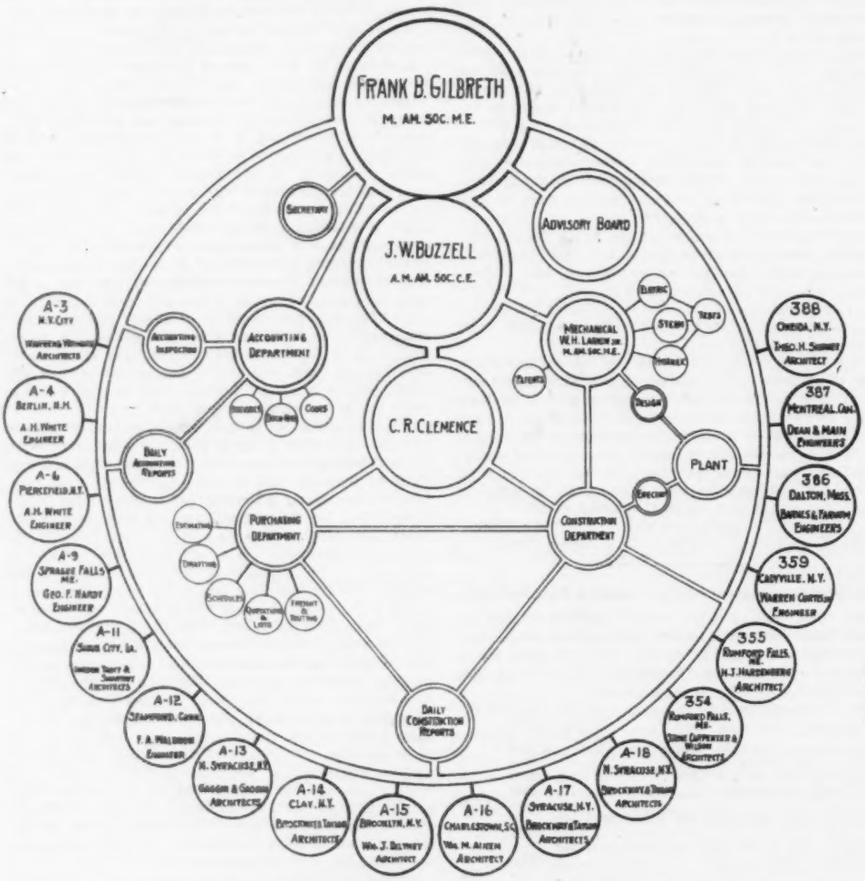
The mode of application of the paper is as follows: After the rust is carefully cleaned off by means of stiff wire brushes, a certain kind of tacky paint is applied, the paper then covered over and tightly pressed upon the painted surface, the joints of the paper slightly lapping. As soon as the paper is in place, it is ready for the outside coat of paint. It will be observed that by this process, the first coat of paint, the paper and the coat of paint over the paper can be applied with one scaffolding, thereby greatly reducing the cost, especially in high and dangerous places.

These experiments, extending over only three years, are of too short a duration to determine the value of paper as a protection for iron and steel, but they certainly bring out the fact, at least in the case of smoke and gases, that the action begins from behind the paint and not from in front by the disintegration of the paint.

*Slightly condensed from a paper read before the American Society for Testing Materials, June 30, 1905.

AN ORGANIZATION CHART OF A LARGE CONTRACTING FIRM.

So long as a contractor has only one or two contracts under way at one time, a very simple system of organization and accounting will suffice. In fact, many contractors of considerable means carry a large part of their business in their head, as the saying is. But when a large number of scattered jobs are to be handled at the same time from a central office, not only must a system of accounting be perfected, but the men in the field as well as the men in the office must fully understand the system. As a help to such an understanding the accompanying chart is of obvious advantage. Blue prints of this chart are hung in a conspicuous place in the local office of each job as well as in the home office. Each contract, it will be seen, is numbered, and the name is given of the architect or engineer under



A CHART OF THE ORGANIZATION OF A CONTRACTOR'S BUSINESS.

whose direction the work is being done. In this particular chart the letter A preceding the contract number indicates that the contract was awarded in New York; whereas, if the letter A is omitted, the contract was awarded in Boston.

All letters, reports and accounts are given the number of the contract to which they refer. The superintendent of each job sends a daily construction report and a daily accounting report to the home office. The construction report gives the number and class of men engaged on the work, and the progress of the work. Requisitions for materials, tools, etc., accompany the report. This report goes to the purchasing department, or to the construction department, or to both departments, according to the nature of its contents.

The daily accounting report consists of a blank properly filled in, showing cash expenditures, tools received and tools shipped to other contracts. It also contains sheets showing that certain goods have been ordered from local dealers at certain prices; and other sheets showing what goods have been delivered.

All reports are made out in manifold books by the superintendents of the different jobs, so that they themselves have carbon copies to refer to. Each report has its serial number, which makes misunderstandings impossible and facilitates cross-references and accounting. This holds true even of the weekly payroll report.

An accounting inspector is provided, whose duty consists largely in visiting new jobs for the purpose of instructing new men in the methods of making reports and of keeping records. It is true that each superintendent is provided with a printed book of rules and instructions, called the "Field System," but, although these rules are full and explicit, it has been found that many of the new men require more or less "coaching" for a week or ten days, and that the head office is saved considerable annoyance and correspondence by having this "coaching" done by a man detailed for the purpose.

While all reports must pass through their proper channels, and do not go to the head of the firm direct, the circular line passing from the head of the firm to the various contracts indicates that he visits the contracts in person.

In addition to this general chart showing the organization, there is a special chart for each contract. Each building and each separate piece of work on a contract is given its own individual number on the chart; and that number is used when making reports and in keeping itemized cost accounts. Photographs are taken at frequent intervals showing the progress of different pieces of work; and on the film is marked not only the date but the number of contract and the number of the particular piece of work, as found on the contract chart.

PILE FOUNDATION FOR MOVABLE DAM, AT McMECHEN, W. VA., WITH METHOD OF CALCULATION.

By Gilbert S. Walker,* M. Am. Soc. M. E.

The lock and dam now being built at McMechen, W, Va., five miles below Wheeling, is one of a system of such locks and dams which will eventually give slack water navigation upon the Ohio River. The dams are all to be of the movable type which can be lowered flat upon the river bottom in time of high water. When the river is low the wooden wickets which form the upper part of the dam will be raised, converting the river into a series of navigable pools. Communication between these pools will be provided for by locks, one at each dam.

These locks and dams were located by the officers of the engineer corps of the army several years ago. The sites were chosen with due regard to many important considerations, such as suitable lift, ample submergence of bars, ease of navigation and management of drift. The character of the foundation on which the work would have to rest seems to have been given but scant consideration. However, the river bed affords such uniformly poor foundations that it is doubtful if much better sites could have been selected.

At McMechen the bed-rock underlying the site is at a nearly uniform depth of about 34 ft. below low water. The material which overlies this is a mixture of sand, gravel and cobble stones of all sizes. Clay or other substances which might give it any cohesive qualities seem to be entirely lacking. It offers very little resistance to the flow of water through it and its angle of repose, when saturated, is only about one on five. It is obvious that this material can not be relied on either to cut off the under flow of water or to support the necessary masonry foundation for the wickets.

The designing of a suitable foundation for a dam at a site like this was particularly difficult and compelled me to study the problem very carefully. Before coming to the details I will enumerate, in the order of their cost, the four principal types of foundations which have been considered:

(1) A concrete or masonry structure built up from the bed-rock.

(2) Cribs sunk to a firm footing on the bed-rock and filled with broken stone.

(3) Rock-filled cribs resting on the sand, sheet piling being depended on to retain the sand under them.

(4) A pile foundation.

The first type might be either a solid mass of concrete of the breadth necessary for stability, or by the aid of some reinforcing steel a combination of piers and curtain walls might be used. With either of these types the permanent structure would be expensive, but a still more expensive item and one threatening to give serious trouble would be the excavation. To keep an excavation through this material open 34 ft. below low water and dry enough to lay concrete in would involve serious difficulties and be far too costly to consider. It might even prove impracticable and necessitate the use of caissons.

With the second type it would not be necessary to remove all of the water from the site. The excavating could be done with dredges at a reasonable unit cost. The cribs could be built at a convenient point, floated out and sunk in position. They could be made in short sections, so that only a small part of the excavation need be kept open at the same time. The cribs would, of course, have bottoms so as to retain the stone filling, and the superstructure would be anchored down to the cribs. While the cribs themselves do not have any stability, they would retain the stone filling and make the whole structure act together. While this plan seems to offer a good and practical solution, its advantages over the fourth type are hardly important enough to warrant the greater expense.

Cribs sunk about 14 ft. into the sand are being used at another dam now under construction on this river. The stability of this type depends on the filling being held in the cribs and the sand

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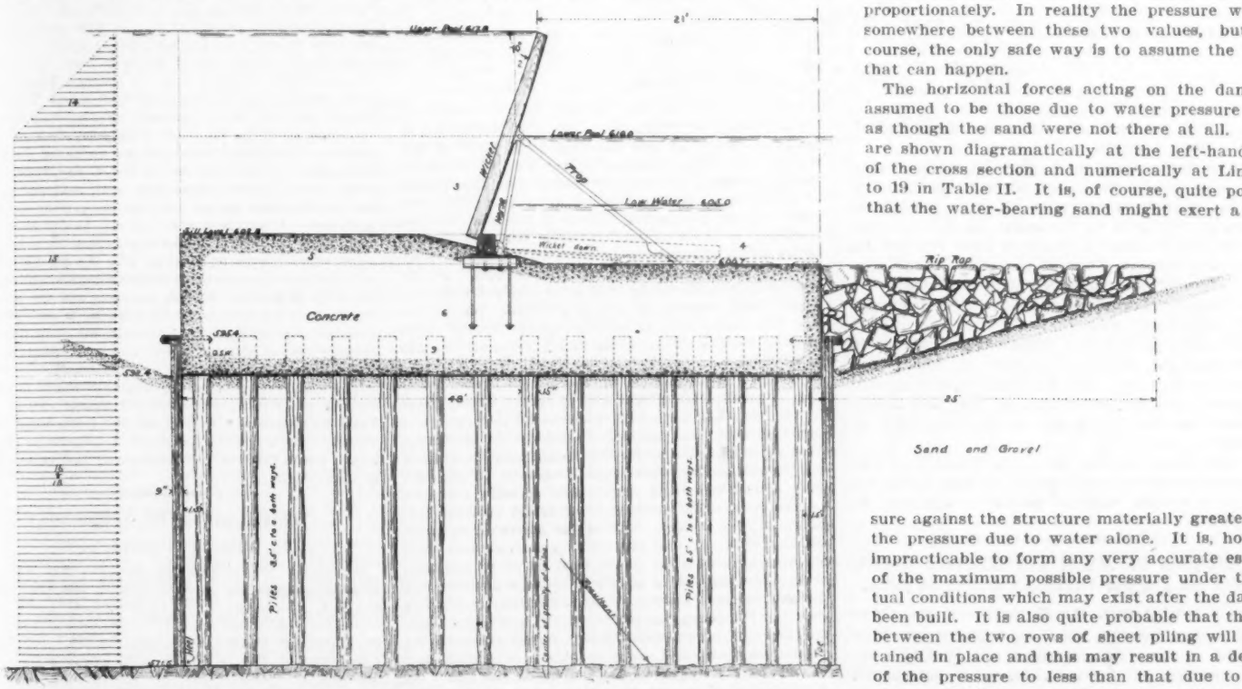
being retained in place. Unless the cribs have bottoms and are filled with rock it is not clear how the stability of the structure will be any greater than though the crib were entirely omitted, leaving the top slab only. Rows of sheet piling are driven along the upper and lower sides of the dam to retain the sand in place and there is always danger that enough sand may escape to cause serious settlement.

As this type also costs from 10% to 15% more than the pile type the latter is to be used.

The fourth type, a cross section of which is shown herewith, is free from all these difficulties. The construction work is all of the simplest kind, which is an important consideration when it is desired to get reasonable bids from the contractors. There is very little excavation as compared with the other types of foundation and none of it is deep or troublesome. Both the sheet piles and the round piles can be quickly and cheaply put down by means of the water jet.

This type of foundation has the great advantage of not having to depend for its stability upon any kind of filling always liable to be washed out, or upon the tightness of sheet piling always liable to leak. The riprap in this design is only



PILE FOUNDATION FOR A MOVABLE DAM AT McMECHEN, W. VA.

of minor importance. It is intended primarily to prevent the water which pours over the dam from scouring a hole in the river bed at the lower side. But in case it is ineffectual in this, it is expected that it will then drop down in the hole so formed and at least prevent the sheet piling from being carried away. The sheet piling on the upper and lower side of the dam is only intended to cut off the underflow of water. If it also succeeds in retaining the sand in place beneath the structure the round piles will be assisted in their work and the stability of the dam improved, but a complete failure of the sheet piling will not imperil the dam.

In order that the pile structure may be stable it is of course essential that the concrete slab shall be sufficiently wide and heavy, and that the piles shall be firmly held in the slab so as to all act together as a single rigid structure.

The method by which I arrived at the most economical width and depth for the slab and the distribution of the piles under it is rather complicated, but I may be able to present it at some other time. The final calculations for stability are reproduced in Tables I. and II. and will be found to contain some interesting features.

Table II. contains all the forces acting on the structure and their moments about the toe of the dam (marked O). Lines 1 to 8 of this table give the weight of the concrete slab and the superincumbent water. For convenience of calculation the cross sections of the concrete and of the water above it are divided into a number of regular geometrical figures. These figures are shown on the diagram by dotted lines and are numbered to correspond with the numbers of the lines in Table II. Their dimensions in feet are set down in Columns 6 and 7 and the distances of their centers of gravity from the base lines are given in Column 9.

The constant 35-32 in Column 3 calls for some explanation. The forces are calculated for a section of the dam 35 ft. in length, so as to include whole numbers of piles in both the heel and the toe. This length is the numerator 35. The denominator comes from the assumption that 1 cu. ft. of water weighs 62½ lbs. or 1-32 of a ton.

Each of the areas shown on the diagram has to be multiplied by the length of dam considered and by the specific gravity of the material, after which the product is divided by 32 to give the weight of the item in tons which appears in Column 8. Hence the figures in Column 8 are found by multiplying together the figures in Columns 3 to 7, inclusive. These weights in turn have to be multiplied by their lever arms to give the moments and therefore the figures in Column 10 are found by multiplying together the figures in Columns 8 and 9.

The factor 35-32 I have multiplied in separately at each line for the sake of greater clearness. It is obvious, however, that it can be omitted from all the work down to the final result, and multiplied in once for all at lines 23 and 24. This will be found to materially reduce the drudgery and the chances of making arithmetical mistakes.

The amount of concrete displaced by the portion of the piles imbedded in the slab is deducted at Line 9 and allowance is made for the buoyancy of the remaining portion of the piles at Line 11.

It is assumed that the lower row of sheet piling is practically water-tight while the upper row is leaky and ineffectual so far as preventing the communication of water pressure is concerned. Consequently, the water from the upper pool will penetrate through the material underlying the dam as far as the lower row of sheet piling. The resulting hydrostatic pressure of 25.4 ft. of water acting upward on the lower surface of the slab is taken account of at Line 10. If the assumptions should be reversed and the upper row of

TABLE I.—Moment of Inertia of Piles in 35 Foot Section of Dam.

1	2 No. of Piles.	3 Arm.	4 Moment.	5 Arm.	6 Moment Inertia.
1.....	14	1.5	21	1.5	31.5
2.....	14	4.0	56	4	224
3.....	14	6.5	91	6.5	591.5
4.....	14	9	126	9	1,134
5.....	14	11.5	161	11.5	1,851.5
6.....	10	15	150	15	2,250
7.....	10	18.5	185	18.5	3,422.5
8.....	10	22	220	22	4,840
9.....	10	25.5	255	25.5	6,502.5
10.....	10	29	290	29	8,410
11.....	10	32.5	325	32.5	10,562.5
12.....	10	36	360	36	12,960
13.....	10	39.5	395	39.5	15,602.5
14.....	10	43	430	43	18,490
15.....	10	46.5	465	46.5	21,622.5
16.....	$n = 170$		$m = 3{,}529$		$I = 108{,}495$
17.....			$\frac{m^2}{n} = \frac{(3529)^2}{170} =$		73,299
18 Moment of inertia.....					$I = 35{,}196$
19 Distance of center of gravity from toe $= \frac{m}{n} = \frac{3{,}529}{170} =$					20.755

sheet piling taken to be practically water tight while the lower row is leaky, then, of course, the hydrostatic pressure would be from the lower pool or 17.6 ft. of water instead of 25.4, and the apparent stability of the dam would be increased proportionately. In reality the pressure will be somewhere between these two values, but, of course, the only safe way is to assume the worst that can happen.

The horizontal forces acting on the dam are assumed to be those due to water pressure only, as though the sand were not there at all. They are shown diagramatically at the left-hand side of the cross section and numerically at Lines 14 to 19 in Table II. It is, of course, quite possible that the water-bearing sand might exert a pressure against the structure materially greater than the pressure due to water alone. It is, however, impracticable to form any very accurate estimate of the maximum possible pressure under the actual conditions which may exist after the dam has been built. It is also quite probable that the sand between the two rows of sheet piling will be retained in place and this may result in a decrease of the pressure to less than that due to water alone. All things considered it would seem that the calculation of the horizontal forces as simple water pressure is a sufficiently close approximation to the truth.

It will be noted at Line 22 that the resultant of all these forces falls 3.15 ft. outside the middle third of the base. This is exactly compensated for by the non-uniform distribution of the piles. The essential requirement is not that the resultant shall fall in the middle third, but that there shall always be a positive downward pressure on all of the piles. This condition is fulfilled as will be seen at Lines 23 and 24 in Table II. In order to arrive at the loads on the piles it is first necessary to find the center of gravity and the moment of inertia of the system of piles, which work can be readily followed in Table I.

The number of piles in each of the longitudinal rows are set down in Column 2 and the distance from their centers to the toe are entered in both Columns 3 and 5. The product of the numbers in Columns 2 and 3 will then give the moments in Column 4 and the latter when again multiplied by the arms will give the moments of inertia in Column 6. Here, also, considerable work can be saved by omitting to multiply in the figures in Column 2 until the corresponding portions of Columns 4 and 6 have been footed up, when the numbers 14 and 10 can be multiplied into the totals once for all. In this case the figures in Col-

TABLE II.—Forces Acting on 35-Foot Section of Dam.

1	2	3	4	5	6	7	8	9	10
	Vertical Forces:	Const.	Sp. G.		Height. ft.	Width. ft.	Weight. tons.	Arm. ft.	Moment. ton ft.
1	Water		1	....	7.8	25	213.3	35.5	7,572
2	Water (triangle)		1	½	7.8	2.83	12.1	22.06	267
3	Water		1	....	7.2	45	378	24	9,072
4	Water		1	....	2.1	26	59.7	13	776
5	Concrete		2.25	....	2.1	22	113.7	37	4,207
6	Concrete		2.25	....	8.3	48	980.4	24	23,530
7	Iron	....	....	....	....	....	16.4	20	328
8	Total weight						1,773.6	....	45,752
9	Pile heads deducted		1.45	170	8	1.23	28.4	20.76	590
10	Hydrostatic		1	....	25.4	48	1,333.5	24	32,004
11	Buoyancy of piles		.20	170	21	.79	17.6	20.76	364
12	....	....	....	....	....	....	1,379.5	....	32,958
13	Net weight						W = **394.1** tons	....	12,794
	Horizontal Forces:								
14	On wicket (triangle)		1	½	7.8	7.8	33.3	41.2	1,372
15	On structure		1	....	7.8	17.6	150.2	29.8	4,476
16	On sheet piling		1	¼	7.8	21	89.6	21	1,882
17	Thrust on structure						273.1	....	7,730
18	....		1	½	7.8	21	89.6	0	0
	Total thrust						T = **362.7** tons	....	7,730
20	Net moment about toe								M = **5,064**

21 Tangent of angle of sliding $\frac{T}{W} = \frac{362.7}{394.1} = .9203$

22 Distance of resultant from toe $\frac{M}{W} = \frac{5,064}{394.1} = \frac{20.75}{7.90} = 12.85$

23 Load on heel pile $= \left(\frac{W}{n} - \frac{M_g}{I} C_b\right) = \frac{394.1}{170} - \frac{394.1 \times 7.90}{35,196} \times 25.75 = 81$ lbs.

24 Load on toe pile $= \left(\frac{W}{n} + \frac{M_g}{I} C_b\right) = \frac{394.1}{170} + \frac{394.1 \times 7.90}{35,196} \times 19.25 = 4.02$ tons.

umn 4 will merely be the arms and those in Column 6 their squares.

If the surrounding sand offers no material support it is obvious that the piles will also have to act as cantilevers to resist all the horizontal thrust which comes on the dam. As this assumption is rather severe a stress of 2,500 lbs. per sq. in. in the extreme fiber of the piles where they enter the slab is considered permissible, and the necessary number of 15-in. piles have been determined accordingly.

Just over the bed-rock there is about a foot of some clay-like material, no core of which was obtained. This material, whatever it may be, will no doubt hold the lower ends of the piles firmly in place so that there will be no possibility of sliding.

It will thus be seen that this foundation has been carefully designed, so as to just fulfill all the requirements without excess of material at any point.

A COMPARISON OF STEAM AND ELECTRIC MOTIVE POWER ON A LIGHT TRAFFIC RAILWAY IN IOWA.

In connection with the discussion of the above topic in our issue of July 20, a paper has been brought to our attention which was read at a recent meeting of the Iowa Street & Interurban Ry. Association by Mr. F. McDonald, Assistant to the President of the Waterloo, Cedar Falls & Northern Ry. Co., operating 35 miles of street railway line and 45 miles of interurban railway in central Iowa. We quote from this paper as follows:

In looking over the proposed interurban lines for Iowa, I find that nearly all the promoters are depending on the freight business from the country districts to furnish a large part of the revenue. We handle freight in carloads on all parts of our line, and have portions which are operated exclusively by electricity, other parts operated entirely by steam locomotives, and some on which both steam and electric motive power are used.

So far as I know we were the first to attempt to build such a line; at least, we were unable at that time to find another road operating under the same conditions. Our president, Mr. Cass, and myself made several trips to different points where electric railways were said to be doing a freight and passenger business, only to find that their freight business consisted of a package or express business. In only one instance did we find a road handling freight in carloads in standard steam railway cars on joint through tariffs with trunk line railways.

In locating a line of this kind it is necessary that a territory be selected in which the competition will not be direct with steam railways already established, the idea being to work in connection with the steam roads as a feeder and not against them, for the farming community alone will never support a railway unless there is a reasonable chance to secure the freight and passenger business in and out of their market towns.

The question of motive power is one of the hardest to decide for a road of this class, and while I realize that this is a convention of electric railway men, I wish to say to any gentleman here who is contemplating the building of a railway through a farming district, consider well your location, prospective volume of business and the frequency of the train service which you wish to give before installing expensive electrical machinery and overhead equipment to operate a line of this kind. On the line out of Waterloo we have 16 miles equipped with electricity, from Waterloo to Denver Junction. We use for this line 20,000 volts alternating current stepped down through transformers and the rotary converters to 550 volts direct current.

For the first six months we operated to Denver Junction by steam, both freight and passenger trains. Then, having completed the installing of electric machinery and overhead work, we operated it entirely by electricity. This we continued to do for about eight months, using in the freight service an electric locomotive of 120 HP. This locomotive would handle five carloads over our heaviest grades, but we found, in operating a freight line, as many of you have found in the passenger business, that we could not take part and let the rest wait until we went back after it. It all must go about the same time. Our business is mainly a through business and depends on connections with the trunk lines at junction points. For example, stock, butter and other time freight must connect with the time freight trains on the connecting lines, and shippers object to loading any earlier in the day than just to make the run. As a rule, also, there are one or two days in the week when all stock men wish to ship in order to reach the market on certain days. We soon found that in order to take care of the business it would be necessary to put into service a much larger locomotive, which meant increasing the capacity of our power station and overhead lines, the added investment to be used only one or at most two days in the week. We studied the matter carefully, making the comparison of operating electric and steam locomotives, both for labor and fuel, and returned to the use of the steam locomotive for the freight business, except for switching at points where the use of a steam locomotive was not practical.

The amount of coal burned on our steam locomotives averages about 1.4 tons per 10,000 ton miles, while for electrical service it is between eight tons and nine tons per 10,000 ton miles. It is true that this is hardly a fair comparison, as the coal used in locomotives is Illinois lump, while that used at the power house is the cheapest Iowa steam, and also for the reason that the steam locomotives have longer runs without stopping, thereby giving them the advantage of the momentum, while the electric cars are operated largely on city lines, where they have to start and stop every few hundred feet.

About two years ago we acquired control of 28 miles of steam railway track between Denver Junction and Sumner. We have never equipped this line for electricity, but have operated it entirely by steam, running two passenger and one freight trains each way per day. The passenger trains are operated the same as the electrical service, stopping to receive and discharge passengers at all highway crossings. We do not find it any more difficult to do this with a light train, consisting of one combination baggage and smoker and one straight [illegible] coach, equipped with air brakes, than with an electric train of the same size. This number of trains takes care of all the regular passenger business without difficulty, and for special occasions we run excursion trains of whatever size is necessary to care for the business. The freight trains make the round trip from Sumner to Waterloo each day, a distance of 45 miles, or 90 miles for the round trip, with one engine and crew.

For passenger business on the rural railway, I have found the advantage of electric motive power over steam is largely a matter of convenience to the public, there being no question but that it is pleasanter to ride in an electric train with no smoke and no odor. On the other hand, the steam train has the advantage of each train having its own motive power. On the electric line, if anything happens to your power house or overhead line, every train on that section of the road is at a standstill until the damage is repaired, and if it is line trouble not far out, considerable time is lost in reaching the location of trouble, especially if you have no steam locomotive or other independent means of reaching the scene of trouble. In snow, I think, with locomotives of the same weight and with the power behind them, the electric will do as good work as the steam, but when it comes to lightning and sleet, the steam locomotives have a decided advantage, and on one of these cross-country lines, over Iowa prairies, the bad sleet storms are as much to be dreaded on an electric line, as the snowstorm. If any one here has discovered a successful way to fight sleet on an interurban trolley wire, I should like to know it.

Our morning train out of Waterloo must make connection at Denver Junction with the Chicago Great Western train for Fort Dodge, Omaha and all points West to the coast. In winter, when we were troubled with the snow, we could count on the other road being delayed by the storm to about the same extent we were, but during the early part of March we had a few sleet storms, which, while not as bad as I have seen, were sufficient to delay our electric train for an hour or more, while the steam train never knew there was a storm, so far as its running time was concerned. No sooner does the weather become warm enough to do away with the trouble of snow and sleet than the trouble of lightning begins. We are protected by tank arresters, pole arresters and car arresters, but still we lose more or less armatures, to say nothing of the loss of controllers, light circuits, etc. We have, fortunately, never lost any generators at our power station.

For switching purposes it is often possible to use an electric locomotive in places where it would be impossible to use steam. For example, on our line at Cedar Falls we switch all the coal for the Iowa State Normal School from the steam railways, a distance of about a mile. We do this over our regular city line on the streets of Cedar Falls.

THE USE OF BOILER COMPOUNDS.*

By William M. Booth, B. S.†

During the fall of 1902 my attention was first called to boiler compounds. A white powder was submitted for analysis, which was found to contain soda ash with a little free tannic acid. It was said that this was used to soften and remove scale from boilers. One concern with which I was connected later had a great deal of difficulty with scale in a buttery of water tube boilers, as the total solids in the water they were using, amounted to 35 grains per gallon, and the scale-forming solids to more than half this amount, consisting largely of sulphate of calcium. I examined the tubes and found a very compact scale about 1-16 in. thick, which it was impossible to remove by mechanical means. Kerosene was tried and was found ineffective. A boiler compound company offered to remove this scale, but when granted every privilege was unable to do so. Indeed, many tubes were burned out while the compound was being used. This liquid was brought to me for analysis. It was black in color, dense, had an odor of caustic soda and was very alkaline. Analysis showed this to contain mainly caustic soda in excess, logwood, tannin, sugar, sulphate of soda, and a small quantity of gum. It is needless to say that its use was prohibited.

The third compound examined contained catechu, caustic soda and tan liquor. These compounds were sold for about 50 cts. per gallon and cost less than 6 cts. to make. They were, of course, 75% or higher water. The examination of a number of samples shows that three basic chemicals are known, even by unscientific men, to attack scale within the boiler itself. These are caustic soda, soda ash, and tannic acid compounds, from sumach, catechu and the exhausted bark liquor from tanneries. A great difference of opinion seems to exist in regard to the correct material to use within the boiler for the purpose under discussion. One engineer of twenty years experience tells me he has used potato water with good results.

I have no hesitancy in saying that caustic soda in large excess is injurious to boiler fittings, gaskets, valves, etc.

*From "The Chemical Engineer" for April.
†Chemical Engineer, Syracuse, N. Y.

That it is injurious in reasonable excess to the boiler tubes themselves, I have yet to prove. Foaming and priming may be caused through excess of caustic soda or soda ash as is well known by every practical engineer. I can strenuously condemn tannic acid, and of the use of its salts, I am fearful. It may unite with the organic matter present in the form of albuminoids and with the calcium and magnesium carbonates present. That it removes scale is an assured fact, that it removes iron with the scale is also assured, as tannic acid corrodes an iron surface rapidly. Compounds of vegetable origin are widely advertised, but often contain dextrine and gum, both of which are dangerous as they coat the tubes with a compact scale not permitting the water to reach the iron. Molasses is acid and has no place in the boiler, and starch substances generally should be denied. I have not investigated the action of kerosene, but know that in large quantity its use must be very dangerous as it is a very volatile oil and must soon leave the boiler and pass over and through the engine.

We now have two materials the use of which in boilers is not prohibited through action upon the metal itself or on account of price. I refer to soda ash and caustic soda. Sodium triphosphate and sodium fluoride have both been used with success, but the cost is several hundred per cent, greater than soda ash. If prescribed as per analysis, in slight excess, there should be no injurious results through the use of caustic soda and soda ash. Would it not be practicable to manufacture an intimate mixture of caustic soda and carbonate of soda, containing enough of each to soften the average water of a given vicinity? That there is a great deal of fraud in connection with boiler compounds generally, I am assured, though probably to no greater extent than in connection with lubricants and other supplies used about mills and manufacturing plants.

A better class of vendors advertise to build a special compound for a special water. Such an arrangement is expensive, excepting on a large scale, in reference to a particular water, for it would mean a score or more of mixing tanks with men to make up the formulas given them by a number of chemists. The less scientific members of the boiler compound guild carefully consign each sample of water to the sewer and send the regular goods. Others have a stock analysis which is sent to customers of a given locality whether it contains iron, lime, or magnesium sulphates or carbonates.

All money, paid in excess of 3 cts. per thousand gallons, for softening water is for the privilege of using a ready made softener. Every engineer and superintendent in charge of a plant should insist that the compound used be pronounced by competent authority free from injurious materials and that it be adapted to the water in use.

Boiler compounds, then, should contain only such ingredients as will neutralize the scale-forming salts present. They should be used by prescription only, so many gallons per 1,000 gallons of feed water. A properly proportioned mixture of soda ought to answer the demands of all plants depending upon this method of softening water in limestone and shale regions. It is to be remembered, that a number of chemical salts, some of which suffer decomposition at the temperature and pressure of the boiler, are always found within the boiler itself, if the feed water is softened by boiler compounds. What occurs chemically, under such conditions, is a question, and salts of magnesium probably suffer considerable decomposition.

However, for small isolated plants, requiring the softening of water, boiler compounds can hardly be replaced on account of the simplicity of their action and use. Their cost should not be prohibitive, and they should render efficient service in connection with the particular style of the boiler. Steam saw mills, cheese factories and small power plants, generally, often cared for by incompetent and careless engineers, require some material easily applied. The honest boiler compound is ready to solve the problem. For plants of from 75 to 150 HP., 24-hour settling tanks will answer the purpose of a softening system. Two tanks, each capable of holding a day's supply and furnished above with lime and soda tanks in common, and provided with sludge valves below, may be used for this purpose. Paddles in each tank capable of thoroughly stirring the contents may be actuated from above. Very large plants are operated on this principle, serving boilers of many thousand horse-power. Such a system has an advantage over a continuous system, in that the exact amount of chemical solutions required for softening the particular water in the tank can be applied For some variations of such a system, several companies have secured patents and are doing a large business. The fundamental principles themselves, are not patentable, and have been used for many years.

THE PHILADELPHIA FILTRATION CONTRACT investigation is to be continued by a board of three engineers selected by Mayor Weaver. These have been joined with Mr. Wm. Barclay Parsons, M. Am. Soc. C. E., of New York, engaged some weeks ago; Major Cassius E. Gillette, Corps of Engineers, U. S. A.; and Mr. John Donald Maclennan, M. Am. Soc. C. E., of Washington, D. C. It will be remembered that Major Gillette discovered the famous Captain Carter frauds at Savannah, Ga., and gave no one peace until they were investigated and Captain Carter was convicted. Major Gillette's services in the present investigation were secured at the suggestion of Hon. Elihu Root, who served as private counsel to Mayor Weaver until the former became Secretary of State. Major Gillette was ordered by the War Department to report to Washington, and was there instructed to go to Philadelphia and assist Mayor Weaver.

A BRICK-FACED CYCLOPEAN MASONRY-IN-CONcrete dam, with a gross height of 144 ft. and length of 1,250 ft., is nearing completion for the water-works of Swansea, Wales. The height of the dam from the rock surface of the river bed to the overflow line is 100 ft.; that is, the structure is carried 37 ft. into the rock and 7 ft. above the overflow line. The original design called for rubble masonry in cement mortar, faced with stone blocks, but on further investigation it was decided to make the change already indicated. The brick facing, both up-stream and down-stream, has an average thickness of 18 ins., and is carefully tied into the body of the dam. Blue Staffordshire brick were used, with pressed brick at the faces and brindle brick outside, all laid in 3 to 1 cement mortar. The foregoing statements have been taken from a paper on the "Swansea Water-Works," by Mr. R. H. Wyrill, M. Inst. C. E., Borough and Water-Works Engineer of Swansea, read before the Incorporated Association of Municipal and County Engineers at a meeting held July 14 and 15, 1905. The author stated that before deciding on this form of construction he experimented "on the relative water-tightness, durability and resistance to frost of stone and blue brick." His studies extended over several months and satisfied him that he would make no mistake in using brick. The author also stated that he knew of only two other instances of the use of brick facings for masonry dams, in both of which the brick were used on the water face, only: a small dam at Remscheid, Germany (about 82 ft. high; see illustrated description, Eng. News, Jan. 30, 1896—Ed.) and a submerged dam at Rhayader. It is not surprising, we may add, that Mr. Wyrill has overlooked the brick-faced arched concrete dam built in 1903 at Ithaca, N. Y. This structure is 30 ft. high above the rock of the gorge, 7¼ ft. thick at the base, and only 1 ft. thick at the crest, and is faced front and back with a single course of vitrified paving brick, 3 × 4 × 9 ins. in size, laid flat in cement mortar and anchored to the concrete every fifth course with bent steel anchors 7 ins. long. Between the brick and the concrete is a 3-in. layer of cement mortar, embedded in which, near the brick, is a steel wire netting, designed to distribute surface temperature stresses.

A BOILER EXPLOSION ON THE BENNINGTON, a gunboat of the United States Navy, occurred July 21 at San Diego, Cal., killing and wounding a large part of the crew. The cause of the explosion is unknown, but it is stated that one boiler was leaking, and while a man was going to repair it the explosion occurred. This explosion caused a second boiler to explode, badly wrecking the vessel, which was beached soon after the accident. Up to the night of July 24 the casualties were reported as 58 killed and 46 wounded.

A VERY POWERFUL SWITCHING LOCOMOTIVE has been built at the Dunkirk shops of the American Locomotive Co. for pushing trains of cars over the summit or "hump" of the gravity switching yards of the Lake Shore & Michigan Southern Ry. The engine is one of an unusual type, with ten driving wheels (0-10-0), and is of great size and weight. The general dimensions are as follows:

Driving wheels (all flanged)	4 ft. 4 ins.
Wheelbase, engine	19 ft. 0 ins.
Wheelbase, engine and tender	54 ft. 5½ ins.
Weight, engine	270,000 lbs.
Weight, engine and tender	419,500 lbs.
Cylinders	24 × 28 ins.
Valve gear	Walschaert
Valves, piston; diameter	1 ft. 0 ins.
Boiler, straight-top; diameter	6 ft. 8 ins.
Boiler, rail to center line	9 ft. 7 ins.
Working pressure	210 lbs.
Firebox, radial stay	108 × 73¾ ins.
Heating surface; tubes	4,422 sq. ft.
Heating surface; total	4,625 sq. ft.
Grate area	55 sq. ft.
Tubes, 447; diameter	2 ins.
Tubes, length	19 ft. 0 ins.
Coal in tender	12 tons
Water in tender	8,000 gallons
Tractive force	55,350 lbs.

THE RAILWAY ACCIDENT STATISTICS collected by the Interstate Commerce Commission show the following totals for the first quarter of the current year: There were 28 passengers and 204 employees killed and 1,651 passengers and 2,062 employees injured in train accidents during the three months ending March 31, 1905. Other accidents to passengers and employees, not the result of collisions or derailments, bring the total number of casualties up to 15,306 (900 killed and 14,397 injured). This is a decrease of 42 in the total number of persons killed as compared with the quarter ending Dec. 31, 1904. The total number of collisions and derailments in the quarter was 3,108 (1,787 collisions and 1,321 derailments), of which 284 collisions and 177 derailments affected passenger trains. The damage to cars, engines and roadway by these accidents amounted to $2,449,248. This is an increase of 27 in the number of collisions and of 131 in the number of derailments as compared with the last preceding quarter.

A PROGRESS REPORT OF THE POTOMAC HIGHWAY bridge, made to Gen. Mackenzie, Chief of Engineers, by Col. S. S. Leach, states that the main bridge and the temporary paving of the approaches will be completed in the early fall and opened to traffic. It will not be possible to complete before next season the short bridge crossing the head of Washington Channel, the work on which has not yet been begun. The financial statement appended to the report shows that of the $1,168,236.44 allotted for the construction of the bridge and the approaches, $625,032.12 was expended during the past fiscal year. Uncompleted contracts cover $361,640 of the amount remaining available for the building of the bridge.

THE INTERNATIONAL RAILWAY CONGRESS will continue to employ French as its official language; but its publications hereafter are likely to be printed in French, English and German. An announcement appears in the "Official Guide" for July from which we quote as follows:

> The official language of the Congress is and will continue to be French. At any session of the Congress the rules provide that at the request of the local section the language of the country where the session is held may be used in common with French. At all times in the past delegates have been accorded special permission to use their native tongues in giving explanations at the meetings of the sections, which explanations are always repeated in French, and as a matter of courtesy only, may be repeated in any other language when so requested.
>
> Before the session of 1895 the proceedings of the Congress and the monthly bulletins were printed in French only. The large number of English and American railway companies which became adherents of the Congress at that time enabled the Permanent Commission to publish the proceedings in English as well as French, and also to publish an English edition of the monthly Bulletin. This plan has since been continued.
>
> All that the German Government desired in connection with its adhesion to the Congress was that the German language should be placed upon the same footing as English. It is understood that the German railways generally will become adherents and contributors to the permanent organization of the Congress, paying enough into its treasury to provide for the publication of the proceedings of the last session in German, and also for the publication of a monthly edition of the Bulletin in German.

CONCRETE BLOCKS FROM REFUSE DESTRUCTOR clinker, made with a hollow concrete block machine, are being made at Swansea, Wales. The machine is operated by hand and makes blocks 20 × 8 ins., × 7½ ins. high, and also halves, quarters and corners. The blocks can be molded with various surface finishes, as desired. The machine is said to be the first hollow concrete block machine ever used in England. It was made by Pettyjohn Brothers, Terre Haute, Ind. The foregoing description is taken from a paper by Mr. George Bell, Assoc. M. Inst. C. E., Borough Surveyor of Swansea, read before the Municipal and County Engineers at a meeting held July 14 and 15, 1905. Mr. Bell comments on the possible future use of destructor clinker concrete blocks as follows:

> If the blocks turn out as stated, their manufacture would be the means of utilizing a considerable portion of the clinker from the destructor, and may help forward the scheme which the Corporation (the borough—Ed.) have in hand for providing cheap and good dwellings for workmen, which are much required at the present time.

A STEEL AND WIRE GLASS CHURCH has been designed by C. E. Eastman, an architect of Des Moines, Ia., for the Methodist Society of that city. In place of a spire or tower the main architectural feature of the design is a large central dome. In the "American Architect" for July 15, 1905, Mr. Eastman describes the church and summarizes the advantages of the material proposed. The entire outer wall and dome is to be of opalescent wire glass in a steel frame, consisting really of two walls 1 ft. c. to c., with an air space between them. The advantages and some of the details of this style of construction are stated by Mr. Eastman as follows:

> Its cost is less than good pressed brick construction—10 to 25% less.
>
> A soft diffused light enters the buildingthrough the walls.
>
> It is fire-resisting to a practical degree, and is easy of repair, new plates can be set as easily as re-glazing a window.
>
> The glass is clamped in position on cushions of asbestos-felt, with provisions for movement of an inch at each division, which will allow of unequal settlement without apparent evidence either inside or outside.
>
> It will not weather-stain or absorb dust.
>
> It is simple in construction; the vertical divisions (4 ft. apart) are made of two steel angles at outside and also at inside surface of wall laced, with the lacing between forming a slot through which the bolts pass with which the clamping bar is secured in position, thus the punching of the clamping bar is not required to be exact.
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> The clamping bar is of wrought bronze of half circle form and is sufficiently stiff to be a nut-lock preventing vibration from releasing the bolts with which the clamping bars are held.

COVERED SEWAGE SLUDGE BEDS have been built at Canterbury, England, as a part of the remodeled sewage works. The beds consist of rough cinders. It is expected that the sludge will dry sufficiently to permit ready handling, and it is said that when easily moved it can be disposed of readily to adjoining farms. Hereafter the sewage of the city will be screened, then pass through detritus tanks and septic tanks and to the sewage farm. There are two detritus tanks, each 30 × 50 ft. × 7½ ft. average depth, giving a capacity of about 85,000 U. S. gallons each; also two septic tanks, each 50 × 100 ft. × 10 ft. deep, with a combined capacity of 450,000 U. S. gallons, or half the dry weather flow. The area of the farm available for the reception of sewage is 42 acres. Mr. A. C. Turley, Assoc. M. Inst. C. E., is city engineer and surveyor, and the foregoing statements are based on a report by him published in the London "Surveyor" for July 7, 1905.

A PORRO PRISM TELESCOPE, made on the same principle as the now well-known Porro prism binocular field glass, has recently been put on the market by Warner & Swasey, of Cleveland, O. As a reconnaissance glass the instrument should greatly interest engineers by reason of its great power combined with very small size and weight. The instrument has two eye-pieces magnifying 24 and 40 dismeters, is 21½ ins. long and weighs only 2½ lbs. A folding tripod and alt-azimuth mounting accompanying weighs only 4 lbs.

A LIGHT RAILWAY 18 miles in length has been built by the Glasgow & Southwestern Ry., of Scotland, from Dumfries through the Cairn valley. Why it is called a light railway is not evident, since it is said to be equal to an ordinary branch line, and its estimated cost was about $35,000 per mile. Heavy clay excavations and excessive amounts of material increased the cost to about $45,500 per mile. It is a standard gage line operated by small locomotives and ordinary cars, and also the steam car illustrated in our issue of July 20.

THE CATARACT RIVER DAM for the water supply of Sydney, New South Wales, will be 145 ft. high between the natural stream bed and "the level of the by wash," and 723 ft. in length at the top. According to our London contemporary, "Water" (June 15, 1905), the excavation for the foundations, which has been in progress for several years past, was practically completed late in the spring of 1905, and at about the same time bids for the construction of the dam had been invited. The excavation work was done by day labor. A government agent was sent to America and elsewhere to visit large works of like character and select the necessary construction plant. He chose, among other equipment, two sets of 1,100-ft. span Lidgerwood tables, one fixed and one movable up and down the stream. A saw mill was erected and used to produce boards and timber from logs cleared from the reservoir area. The care of the workmen and the sanitation of the camp is described by "Water" as follows:

All single men are housed in barracks, every two men having a separate compartment; married people being located in approved cottages, built at their own expense on ground allotted them. There are several general stores and shops, a reading room, places of amusement run by private enterprise, and the sanitation of the whole township and works is carefully attended to. A dry earth system is installed for nightsoil, which is removed beyond the catchment area of the dam, and all lighter sewage, drainage, etc., is treated by septic tanks and filter beds.

Although not directly stated, it appears that the dam will be composed of concrete. Two rock-crushing plants are already at work: One at a basalt quarry, six miles distant, consists of Gates crushers with a capacity of 60 long tons of rock per hour; the other, also composed of Gates crushers, is located near the dam and crushes material for use as sand. After being screened this crushed material is cleaned by an ejector washer.

THE METROPOLITAN ELEVATED RY., of Chicago, has secured the passage of a city ordinance granting it the right to handle freight and express business, the purpose being to operate this traffic in connection with the Aurora, Elgin & Chicago Electric Ry., whose passenger cars now run over the Metropolitan company's elevated lines to its new terminal on Fifth Ave., between Jackson Boulevard and Van Buren St. Milk, express matter and light freight are expected to be handled. The ordinance is for ten years and the city is to receive 5% of the gross annual receipts for the first five years and 10% for the second five years.

PERSONALS.

Mr. T. M. Mendala has been appointed City Engineer of Juarez, Mexico.

Mr. O. B. Stevens, State Commissioner of Agriculture for the past six years, has been appointed Railroad Commissioner of Georgia.

Mr. Henry Rustin has been appointed Chief Engineer for the Omaha Water Co., of Omaha, Neb., to succeed the late Captain Reynolds.

Mr. F. Montilla, Engineer of Maintenance for the District of San Juan, has been appointed Assistant Superintendent of Public Works of Porto Rico.

Mr. L. J. Proctor, formerly Assistant Superintendent of Public Works of Porto Rico, has been appointed Assistant Commissioner of the Interior for Porto Rico.

Mr. Lucien Hillabrandt has been appointed Superintendent of Streets and Water-works of Johnstown, N. Y., to succeed Mr. John A. Karg, resigned.

Mr. Charles F. Hamilton has resigned his position as City Engineer of Franklin, Pa., to accept a position in the Pennsylvania State Engineering Department.

Mr. Thomas F. Nichols, Professor of Applied Mathematics at Hamilton College, has been appointed Assistant Engineer in the New York State Engineering Department.

Mr. Charles H. Brown, of Mann's Choice, Pa., and Miss Helen A. Tolford, of Portland, Me., were married July 19 in that city. Mr. Brown is a chemical engineer with the U. S. Leather Co.

Mr. H. W. Parkhurst, M. Am. Soc. C. E., of Chicago, who has opened an office for consulting engineering practice, as noted in our issue of July 13, still retains his connection with the Illinois Central R. R.

Mr. J. J. Jiminez has been appointed Superintendent of Public Works of Porto Rico, to succeed Mr. P. F. Fernandez. Mr. Jiminez is a graduate of the Civil Engineering Department of Lehigh University.

Mr. Charles B. Clark, heretofore Assistant Engineer of the Cleveland, Cincinnati, Chicago & St. Louis Ry., has been appointed Chief Engineer of Maintenance of Way of that road and of the Peoria & Eastern Ry.

Mr. C. G. Delo, hitherto Division Engineer of the Chicago & Great Western Ry., at Des Moines, Ia., has been appointed Engineer of Maintenance of Way of the Western Division, with headquarters at Kansas City, Mo.

Mr. James L. Tighe, City Engineer of Holyoke, Mass., has sailed for Europe, where he will spend a couple of months. Mr. Timothy J. McCarthy, Assistant City Engineer, is in charge of the Engineering Department during Mr. Tighe's absence.

Mr. Charles L. Crandall is now in charge of the grade-raising operations in Galveston, Tex., as the chief representative of Goerhart & Bates, the contractors. Mr. M. P. Goerhart, a brother to the senior member of the firm, who has been in charge of the work since its inauguration, has retired from the management, and will return to Germany, where he has other interests demanding his attention.

Mr. E. A. Handy, M. Am. Soc. C. E., heretofore Chief Engineer of the Lake Shore & Michigan Southern Ry., has been appointed Assistant General Manager of that road, with headquarters at Cleveland, O. Mr. Samuel Rockwell, M. Am. Soc. C. E., heretofore Assistant Chief Engineer, succeeds Mr. Handy, and is in turn succeeded by Mr. G. C. Cleveland, heretofore Assistant Chief Engineer of the Lake Erie & Western R. R.

Mr. Frederick E. Gunnison, of Brooklyn, N. Y., has been nominated by Governor Higgins of New York as the third member of State Gas Commission. Mr. Gunnison, who will be President of the Commission, was named in place of Mr. James R. Sheffield, of New York City, who declined the appointment. The other members of the Commission are Judge L. L. Shedden, of Plattsburg, N. Y., and former Attorney General John C. Davies, of Camden, N. Y.

Major Cassius E. Gillette, Corps of Engineers, U. S. A., has been selected as the third member of the expert commission which is to investigate the filtration, boulevard and other public improvement contracts of Philadelphia. The other members of the commission are Mr. William Barclay Parsons, of New York City, and Mr. John Donald Maclennan, of Washington, D. C. Considerable interest is attached to the appointment of Major Gillette, as it was he who was chiefly responsible for unearthing one of the greatest scandals in the history of the United States Army—the Captain Oberlin M. Carter case, at Savannah, Ga.

Mr. Jackson Smith, the recently appointed Assistant to Mr. John F. Stevens, Chief Engineer of the Isthmian Canal, has had a great deal of experience in railroad work, most of this being obtained with the Louisville & Nashville R. R., with which road he was often in the special service of the President, Mr. Milton H Smith. During his service with the Louisville & Nashville, he was often made receiver for small roads, as a rule operated in the interests of the larger roads. He completed a number of these smaller lines and put them on a paying basis. Mr. Smith's last service was with the National Railroad lines of Mexico as General Passenger Agent and Assistant to Vice-President Metcalf, who acted as General Manager of the entire system. His residence has been in Mexico for the last two years, most of the time in Mexico City. For about three years previous to his work on Mexican railroads, Mr. Smith was engaged in railroad construction in Ecuador. His most important work there was building the railroad between Quito and Guayaquil, and here the labor question was the hardest one to solve. This Mr. Smith accomplished with great success, importing laborers from wherever they could be secured. At one time he obtained 5,000 Jamaicans through a contract with the Jamaican Government. While in Ecuador Mr. Smith visited the Isthmus of Panama a number of times, and became familiar with the Panama Canal construction work then carried on by the French. During his Ecuador work he especially perfected systems of timekeeping, and he managed the labor so as to avoid having the company swindled by the workmen, as is too often the custom in that section of the world. Mr. Smith is a native of South Carolina, being born in Marion in 1864. His last residence in the United States for a number of years has been Cincinnati, with the exception of a few months in New York, when he was closing up the reports on the Ecuador work. He has written a number of interesting articles for the magazines on railroads and railroad construction, and is a thoroughly practical man. Mr. Smith sailed with the party of Commissioners and Engineers from New York for Panama on July 20th.

Obituary.

Dr. D. P. Hallock, for many years President of Mercer University, died July 24, at Monroe, Ga.

W. L. Prather, President of the Texas State University, died suddenly July 25 at Austin, Tex., of heart failure.

Senator Borelli, who was one of the Chief Engineers in the construction of the Mount Cenis tunnel, died July 22 at Genoa, Italy.

Joseph Holt Gates, an electrical engineer, died July 13, at his home in Chicago, after a brief illness. He was born in Brooklyn, N. Y., in 1861.

Birdsall Cornell, for a long time connected with the C. B. & J. M. Cornell Iron Works, in New York City, died July 22, aged 75 years.

Edward W. Nash, President of the American Smelting & Refining Co., died July 22, at his home in Omaha, Neb., from the effects of a stroke of paralysis sustained on May 22.

Phineas Bronsdon, a pioneer constructing engineer of the Pacific Coast, died July 19, at his home in San Francisco, Cal. Mr. Bronsdon's engineering and constructive talents were largely employed in work on the Pacific Coast, but it is interesting to note that his first engineering work was in connection with the construction of the Public Gardens of Boston, Mass., and the installation of the first horse-car line operated between that city and Charlestown. In 1858 he came to San Francisco, and in 1862 he completed the Omnibus line, said to be the first horse-car system on the Pacific Slope. The preceding year he had built the old San Francisco & San Jose R. R. He also built several traction lines in San Francisco, and for a time managed the Portland Street Ry. system, which he had also constructed. He was the constructor of the Pico Street Ry. in Los Angeles, which is said to be the first trolley system established on the Coast, and the third in the United States. He was 73 years old.

ENGINEERING SOCIETIES.

COMING MEETINGS.

NATIONAL IRRIGATION CONGRESS.
Annual convention, Portland, Ore., Aug. 21-4. Secretary, Tom Richardson, Portland, Ore.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

INTERNATIONAL ASSOCIATION OF MUNICIPAL ELECTRICIANS.
August 23 to 25, 1905. Annual convention at Erie, Pa. Secy., F. P. Foster, Corning, N. Y.

AMERICAN PUBLIC WORKS ASSOCIATION.
August 30, 31, 1905. Annual meeting at Chattanooga, Tenn. Secy., W. H. Flint, Chattanooga, Tenn.

AMERICAN SOCIETY OF MUNICIPAL IMPROVEMENTS.
Sept. 5 to 7. Annual meeting at Montreal, Canada. Secy., Geo. W. Tillson, Brooklyn, N. Y.

ROADMASTERS & MAINTENANCE OF WAY ASSOCIATION.
Sept. 12, 14. Annual meeting at Niagara Falls, N. Y. Secy., C. E. Jones, C., B. & Q. Ry., Beardstown, Ill.

AMERICAN ELECTROCHEMICAL SOCIETY.
Sept. 18 to 20. Annual meeting at Bethlehem, Pa. Secy., S. S. Sadtler, 39 S. 10th St., Philadelphia, Pa.

CONCRETE BLOCK MACHINE MANUFACTURERS' ASSOCIATION OF THE UNITED STATES.—The officers of this association, whose meeting was reported in our issue of July 6, are as follows: President, J. F. Angel; Vice-President, O. V. Miracle; Treasurer, C. C. Huston; Secretary, S. L. Wiltse, Jackson, Mich.